MODEL

D.M.A.- 5/X

SOLID STATE POWER AMPLIFIER

INSTRUCTION MANUAL

M706710F Serial No.11 and up

0688

LING ELECTRONICS, INC.

MP MASTER
MA29145

"LUDA"

CK 202 AIR FLOW 125H
CONVERSION KIT
SENSOR

#CK202-390

#713125- #149.56
LOGIC MONITOR

MODEL

D.M.A.- 5/X

SOLID STATE POWER AMPLIFIER

INSTRUCTION MANUAL

M706710F Serial No.11
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Notwithstanding the provisions of the Warranty stated above, Permanent Magnet Shakers are warranted for a period of 90 days from date of shipment, and all Warranty repairs will be performed at LING's factory.

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LING DIGITAL AMPLIFIER
DMA-5 SERIES

[For the first time user of LING Digital Amplifiers or related high power electrical equipment, please read through this entire manual to assure a proper installation and safe and knowledgable operation.]

Section 1
INTRODUCTION

1.1 DESCRIPTION

The LING D.M.A. product line is a series of efficient, air cooled, modular high power solid state amplifiers designed for continuous operation in vibration testing when used with appropriate shake tables and instrumentation. DMA is an acronym for Digitally Modulated Amplifier (Class D) and consists of three (3) major sections:

- A POWER SUPPLY section for FIELD, ARMATURE and CONTROL.
- A CONTROL MODULE which contains the MODULATOR and LOGIC for the protective interlocks.
- A variable number of POWER MODULES of 4 kVA each.

The POWER MODULES convert power from the ARMATURE POWER SUPPLY section, under control of the MODULATOR, into a variable amplitude and frequency drive for the shaker armature. The cabinet and power supply is large enough for up to 5 output POWER MODULES. The DMA-5 mainframe is also able to accept a maximum of 22.75 inches (578mm) of instrumention.

The amplifier may run from a wide selection of input line voltages and does not require any special operating environment or support equipment.

The DMA-5/X family of amplifiers would be used in a typical system with an appropriately matched shaker and instrumentation system. The instrumentation may include signal generation (either sine or random) equipment such as:

- LING model DCS-7000SR (sine and/or random spectrum generation)
- LING model SCO-1000 (swept sine signals)
- LING model CO-101 (swept sine signals)

Additional support equipment may include protection, convienience and monitoring instruments such as:

- LING Model TAP-1000 (test article protector)
- LING Model VM-100 (vibration monitor)
- LING Model VS-100 (vibration servo)
- LING Model MXA-100 (multiplexer/averager)
- LING Model MLP-102 (multilevel programmer)

Feedback accelerometers are necessary to close the loop from the test payload to the servo-ing unit, signal generator and amplifier. Some instruments include the necessary accelerometer charge amplifier. Additional charge amplifiers may be added to the equipment complement to monitor various payload points.

Refer to the system interconnect documentation and instrumentation manuals for more detailed information before powering up your system.

Field service assistance is available for customers with unique requirements.

1.2 Terminology

For the purposes of this manual, the following terms may be used interchangeably.

POWER MODULE, OUTPUT MODULE POWER SWITCH or SWITCH MODULE all refer to assembly # 712487 or # 713628, one of the basic amplifier building blocks; a minimum of one (1) is required in every system.

LOGIC MODULE, MODULATOR or CONTROL MODULE all refer to assembly # 712564 or # 712724. One (1) is required in every system.

Power ratings:

The POWER MODULES are kVA rated, 4kVA for each POWER MODULE. The POWER SUPPLY section is kW rated. Kilowatts (kW) is real power and kilo-Volt-Amps (kVA) is apparent power. The relationship is:

kW = kVA * power factor (p.f.)

The POWER MODULES can supply real or apparent power as indicated in Table 4.1.

Abreviations: CW = clockwise, CCW = counter clockwise
GND = ground, FET = field effect transistor
RMS = root mean square
RFI = radio frequency interference
FCC = Federal Communications Commission

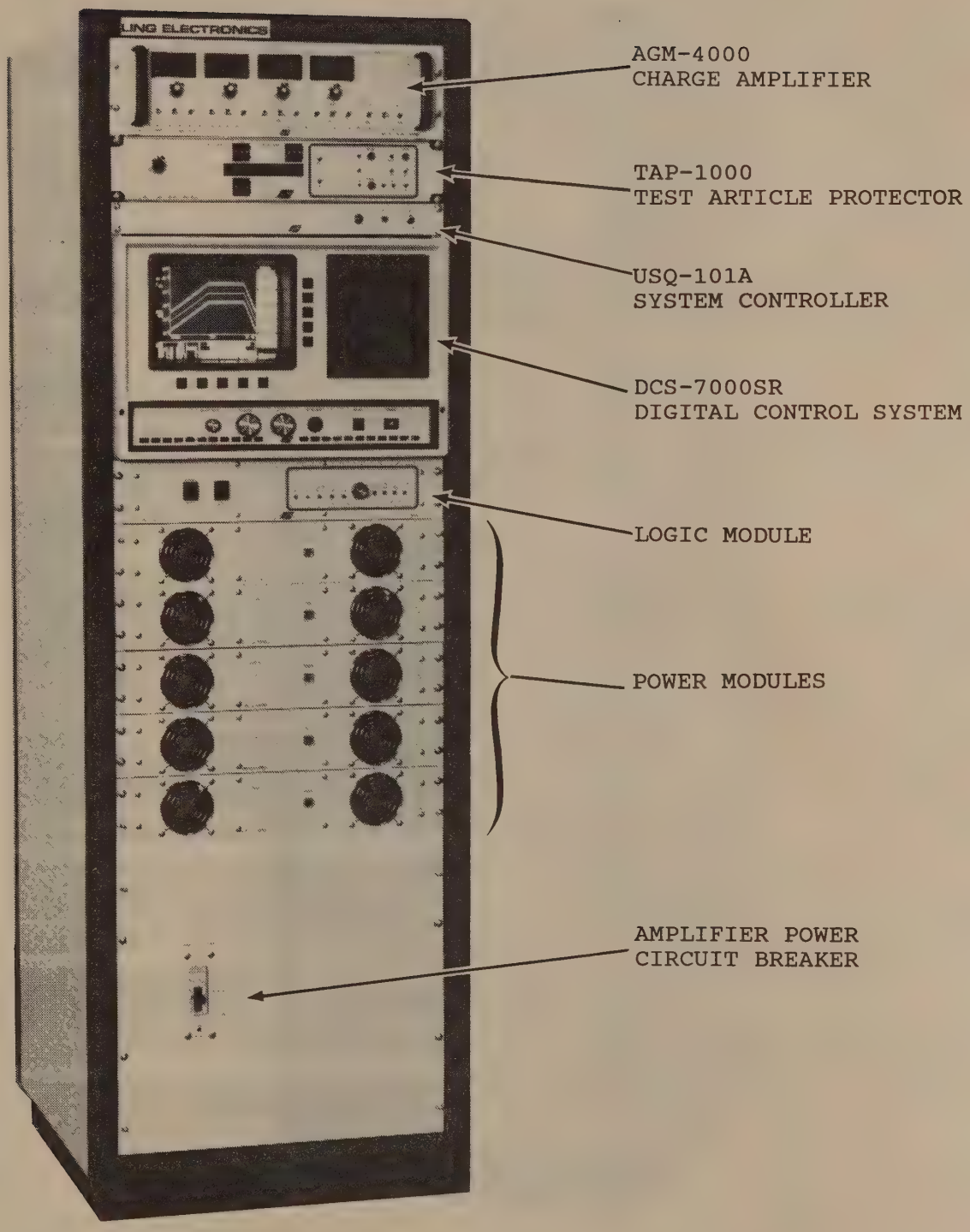

Figure 1-1

DMA-5 WITH INSTRUMENTATION COMPLEMENT

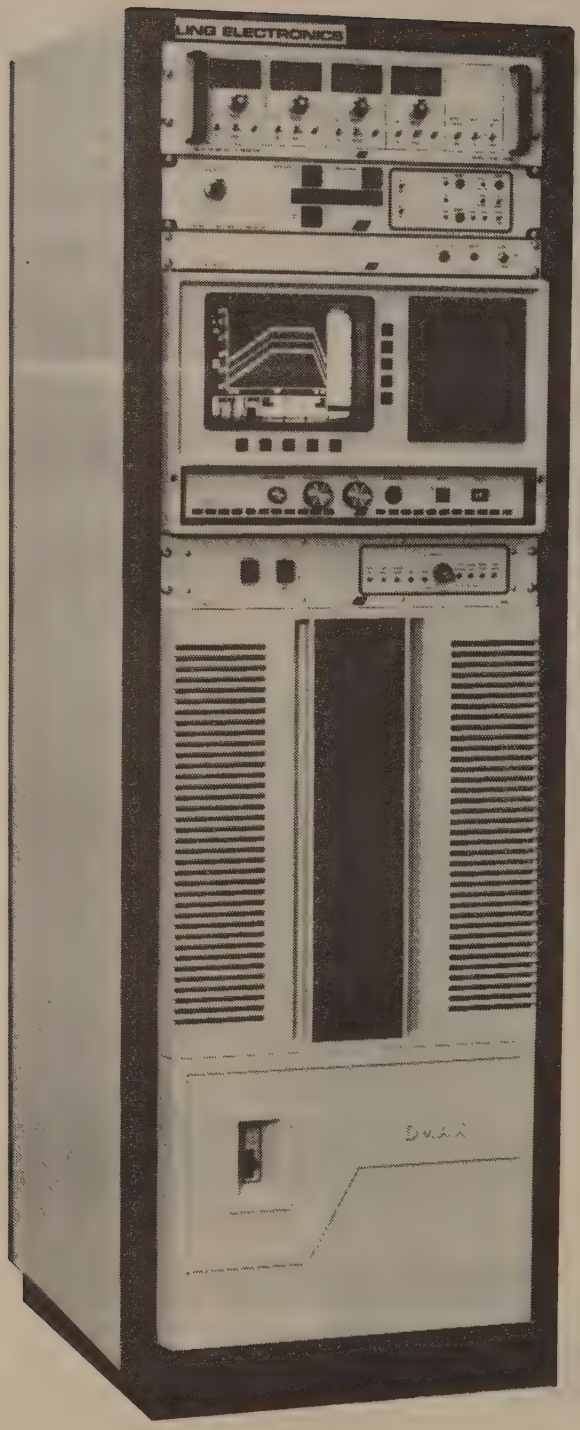

Figure 1-2

DMA-5 WITH FRONT DRESS PANELS

SECTION 2
INSTALLATION

2.1 Receiving Inspection

Match each item of the shipment with line items of the shipping documents. Inspect all items of the shipment for apparent external damage before accepting delivery. Notify the shipping agent and obtain a signed acknowledgement of any apparent damage before accepting the shipment. Do not sign a waiver of concealed damage until all units have been unpacked and inspected.

2.2 Unpacking

Remove any external tie-downs and wrapping material. Leave any internal shipping braces in place until the amplifier is on final location at its installation site.

2.2.1 Moving and Transporting

All moving should be done with the unit in its normal upright position. Consult the LING factory if it is necessary to use any unusual procedures to get the amplifier into installation position. The amplifier may be moved with a fork lift or pallet jack. Lift from the base only, using common sense rigging techniques. The unit is not top heavy and, depending upon the configuration ordered and options, will weigh 500 to 800 lbs (227 to 363 kg).

2.2.2 Special Equipment and Situations

Some, more fragile, instruments will be shipped separately. Do not install any separately shipped equipment until after the amplifier is on final location.

If the amplifier has been specially packaged at your request or wrapped for tropical or marine shipment, leave these special wrappings on as long as possible.

2.3 Location Considerations

Locate your amplifier/instrumentation system in the most efficient manner for greatest production throughput. All front panel controls should be easily accessible and visible for the operator(s) and still allow adequate working room to perform fixturing and testing.

Areas of high DUST, HEAT (over 40°C) or HUMIDITY should be avoided since the amplifier and instrumentation are air cooled and these type environments will only increase maintainance requirements.

2.3.1 Ventilation

The transformer and power supply are both air cooled by convection only. Therefore,

----> DO NOT BLOCK THE NATURAL CONVECTION AIR FLOW REQUIRED AT THE BOTTOM FRONT AND REAR OF THE CABINET BY BLOCKING THE AIR INTAKE SPACE BETWEEN THE FLOOR AND THE CABINET FRAME. ALLOW AT LEAST 18" (457mm) BETWEEN THE AMPLIFIER'S REAR VENTILATION SCREEN AND ANY OBSTRUCTIONS. IF THIS IS NOT POSSIBLE AUXILIARY FORCED VENTILATION WILL BE REQUIRED.

2.3.1.1 Thermal Considerations

Impact on any air conditioning system will be 2750 BTU/hr/module at full output. Effects of a complete system varies with shaker model and blower. For complete analysis, request Ling Engineering Data Report #366.

2.3.2 National Electrical Code (U.S.A.)

The electrical code requires grounding of all cabinet and shaker frames for safety. Refer to LING installation drawing #712710 for required ground conductor sizes. A ground impedance or less than 0.5 ohm is recommended. Additionally, for greatest noise suppression, a solid earth ground rod is recommmended within 6 inches (152mm) of the cabinet. Similarly, the amplifier should not be operated with any of its doors, panels or covers removed.

WARNING
** LETHAL VOLTAGES EXIST IN THE CABINET **

The Code requires a WORKING CLEARANCE of 42" (1.07m) to any live components when performing maintenance or troubleshooting on the amplifier with panels removed. The amplifier must be installed in complete compliance with article 110-16 of the National Electrical Code.

All GROUND wires are to be GREEN or GREEN with YELLOW stripe. This color can be used for no other purpose.

2.3.3 Cable Routing

Route the FIELD, ARMATURE and INTERLOCK umbilical cables in the most direct and protected manner between the amplifier and shaker station. Some form of protection is preferred such as a cable tray, wiring trough or gutter. The high power ac cable to the shaker armature is not shielded; therefore, avoid running low level or un-shielded signal cables in close proximity to its magnetic field.

2.4 Connections

Insure that all connections will be made in the most workman-like manner, marked and checked for tightness.

2.4.1 Line Input Power Installation

The amplifier was tested and shipped from LING with the input power configuration as requested on your order. If it has now become necessary to use a different input voltage, you may now have to change the input circuit breaker and primary wiring to the amplifier's power transformer.

> NOTE
>
> OBTAIN THE SERVICES OF A QUALIFIED ELECTRICIAN AT THIS TIME TO INSTALL THE PRIMARY POWER COMPLIANT WITH LOCAL CODES AND TO VERIFY YOUR AVAILABLE INPUT VOLTAGE.

Instruct your electrician to terminate the input power line in JB-1. This junction box is located behind the lower front cover, next to the main circuit breaker and covers the end of the line input filter. For maximum RFI/EMI protection the conduit system for the input power line must extend to this junction box.

Terminate the power line phases, neutral (if available) and building safety ground on the marked terminals of the power line input filter.

Do not rely on the conduit system for ground. Install a dedicated ground wire as indicated on LING Drawing #712710.

2.4.2 Cables - FIELD, ARMATURE and INTERLOCK Installation

The DMA series amplifiers are intended to be primarily interfaced with the LING air cooled family of shakers such as models 385, 390, 395 and the larger 520 series of shakers.

The FIELD, ARMATURE and INTERLOCK cables are pre-made in standard 20 foot (6m) lengths with quick connect, non-interchangeable connectors on the shaker end and are marked and prepared for connection to their respective terminal blocks on the amplifier end. All user interconnects are accessible behind the lower rear cover of the power supply section. A cable exit cutout is provided in the lower corner of this cover.

NOTE for 395 series shakers -

The 395 series shakers require (2) armature power cables. These cables are identical and are connected in parallel. Do not run the system with only one cable connected. It is also VERY important to maintain color coding when connecting these armature cables. Connect ALL red "H" leads to the "H" terminal block in the amplifier, also all of these wires must pass through the system current sensor as mentioned in Sub-Section 2.4.3. Similarly, connect ALL black "J" wires to the amplifier "J" terminal block.

Remove the lower rear cover and attach the H & J leads of the ARMATURE cable to the large terminal blocks marked "H" & "J" at the lower right of this chassis - Refer to Figure 2-1.

> **NOTE**
>
> It is important to route the H lead to the shaker thru the center of the system current sensor doughnut. (T2 in Figure 2-1).

CAUTION

This current sensor is not a standard current transformer; do not attach any other metering to its output terminals or the system current limiting may be affected.

Similarly, attach the slightly smaller shaker "N" ground lead of the ARMATURE cable to the terminal block marked "N" immediately to the left of the "H" & "J" block. The next two terminal blocks to the left receive the "E" & "F" leads from the FIELD cable.

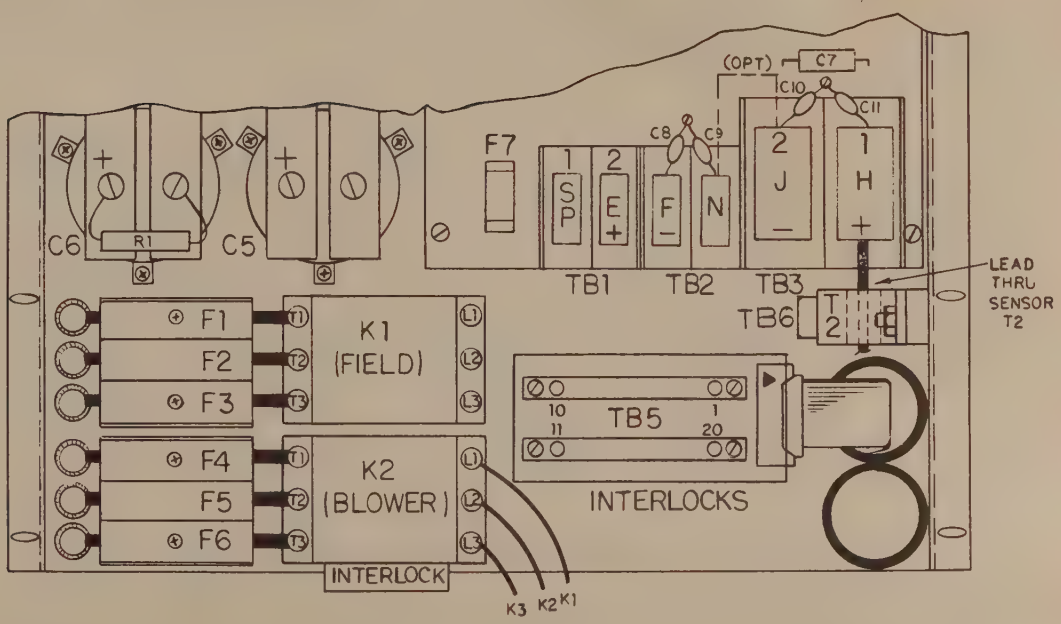

Figure 2-1

CABLE TERMINATION POINTS

2.4.2 Cables - Field, Armature and Interlocks (cont.)

The required standard protection interlocks are shaker air flow and shaker overtravel. Connect the five (5) wires of the standard interlock cable as marked to TB5 on the power supply chassis. This is the ribbon cable adapter board near the lower right corner.

Refer to Figure 2-1, connect:

TB5-1,2	Air flow switch
TB5-3,4	Overtravel switch(es)
GND	Shield, connect to mounting screw near TB5-1

If an over temperature switch is to be used, connect between TB5-5 & 6. Any additional interlock switches may use either terminal pairs 6 & 7 or 11 & 12. Refer to wiring diagram # 712546. Interlocks may be either contact closures or equivalent gates or transistors. Each interlock may be selectivly enabled or disabled by a switch bank on the LOGIC/MODULATOR circuit board. Refer to the Turn on Checkout Procedure (Section 2.6) for setting of these internal switches.

2.4.3 Grounding, Armature Output

The amplifier's armature output terminals may be referenced to ground if desired for system stability or if forced by the construction of the shaker. If you are grounding the shaker, or one leg of the armature is grounded, it is important to connect that grounded leg to the "J" terminal, not the "H". This is to insure that all armature current will pass through the system current sensor T2. If the "H" lead were to be grounded, some current may bypass the sensor by flowing in the "N" lead, leading to inaccurate system current limiting. Refer to schematic #712546 for any further information.

2.5 Radio Frequency Interference (U.S.A. Versions)

This amplifier is crystal controlled and uses digital techniques to sample and convert the input analog waveform into a pulse width modulated signal to drive the power digital switches. Any RF energy created is contained within the cabinet. As the user, you must maintain the integrity of the enclosure, its line filter and shielding gaskets. Any added cabinet penetrations must be made with grounded conduit systems.

Operation of this equipment in the U.S.A is governed under the U.S.A CODE OF FEDERAL REGULATIONS Volume 47 part 15 subpart J.

Do not operate the amplifier with any panels or screens removed or with attaching hardware missing.

NOTE

THIS EQUIPMENT COMPLIES WITH THE REQUIREMENTS IN PART 15 OF FCC RULES FOR A CLASS 'A' DEVICE. OPERATION OF THIS EQUIPMENT IN A RESIDENTIAL AREA MAY CAUSE UNACCEPTABLE INTERFERENCE TO RADIO AND TV RECEPTION REQUIRING THE OPERATOR TO TAKE WHATEVER STEPS ARE NECESSARY TO CORRECT THE INTERFERENCE.

Vol.47 Code of Federal Regulations sect.15.816

2.6 Setup and Turn On Checkout Procedure

Perform the checks of this section in order; especially if this is your first amplifier/shaker installation.

2.6.1 Verify Line Input Voltage

Temporarily disconnect the shaker field cable by unplugging it at the shaker. De-energize the power feeding the amplifier and remove the circuit breaker mounting panel to gain access to the line side of the circuit breaker. Leave the circuit breaker mounted on this panel in the "off" position. With the circuit breaker in a safe position, re-energize the power feeding the amplifier cabinet.

DO NOT TURN THE CIRCUIT BREAKER ON AT THIS TIME. Verify the voltage on the line side of the amplifier circuit breaker. If the voltage is more than 10% high or low, de-energize and change the primary taps on the power transformer according to the following chart:

Standard factory connection is for 480 V wye unless otherwise requested. Note that if one of the delta connections must now be used, the main circuit breaker must be changed to a larger size as well as the wiring to the power transformer primary. Refer to LING schematic #712546.

Other, less common, voltage combinations are possible. For a complete list, refer to sheet 2 of LING drawing #712546.

Line Voltage	Tap	Input on Term.	Jumpers
198V DELTA	- 5 %	4A,4B,4C	3A-4B,3B-4C, 3C-4A
208V DELTA	Nominal	4A,4B,4C	2A-4B,2B-4C, 2C-4A
220V DELTA	- 5 %	5A,5B,5C	3A-5B,3B-5C, 3C-5A
230V DELTA	Nominal	5A,5B,5C	2A-5B,2B-5C 2C-5A
240V DELTA	+ 5 %	5A,5B,5C	1A-5B,1B-5C, 1C-5A
380V WYE	- 5 %	5A,5B,5C	3A-3B-3C
400V WYE	Nominal	5A,5B,5C	2A-2B-2C
416V WYE	+ 5 %	5A,5B,5C	1A-1B-1C
460V WYE	- 5 %	6A,6B,6C	3A-3B-3C
480V WYE	Nominal	6A,6B,6C	2A-2B-2C
504V WYE	+ 5 %	6A,6B,6C	1A-1B-1C

Table 2-1A

LINE VOLTAGE CONNECTION CHART
PT-1390 TRANSFORMER

Line Voltage	Tap	Input on Term.	Jumpers
209V DELTA	- 6 %	4A,4B,4C	3A-4B,3B-4C,3C-4A
220V DELTA	Nominal	4A,4B,4C	2A-4B,2B-4C,2C-4A
230V DELTA	+ 6 %	4A,4B,4C	1A-4B,1B-4C,1C-4A
254V DELTA	- 5 %	5A,5B,5C	3A-5B,3B-5C,3C-5A
265V DELTA	Nominal	5A,5B,5C	2A-5B,2B-5C,2C-5A
277V DELTA	+ 5 %	5A,5B,5C	1A-5B,1B-5C,1C-5A
290V DELTA	- 4 %	6A,6B,6C	3A-6B,3B-6C,3C-6A
305V DELTA	Nominal	6A,6B,6C	2A-6B,2B-6C,2C-6A
320V DELTA	+ 4 %	6A,6B,6C	1A-6B,1B-6C,1C-6A
362V WYE	- 6 %	4A,4B,4C	3 TO 3 TO 3
381V WYE	Nominal	4A,4B,4C	2 TO 2 TO 2
400V WYE	+ 6 %	4A,4B,4C	1 TO 1 TO 1
440V WYE	- 5 %	5A,5B,5C	3 TO 3 TO 3
460V WYE	Nominal	5a,5b,5c	2 TO 2 TO 2
480V WYE	+ 5 %	5A,5B,5C	1 TO 1 TO 1
503V WYE	- 4 %	6A,6B,6C	3 TO 3 TO 3
528V WYE	Nominal	6A,6B,6C	2 TO 2 TO 2
554V WYE	+ 4 %	6A,6B,6C	1 TO 1 TO 1

Table 2-1B

LINE VOLTAGE CONNECTION CHART
PT-1407 TRANSFORMER

2.6.2 Check Connector Installations

Insure that all power module ribbon cables and power connectors are installed correctly and fully seated. The ribbon cable color stripe must align with the pin 1 triangle on its respective header.

2.6.3 Check Shaker Cables

Check correctness of the external cabling; especially the polarity of the field cable (term. "E" is positive). If this is wrong, the free-wheeling field diode in the shaker will be destroyed.

2.6.4 Check Switches in Control Module

Perform this step only if a problem is encountered with the trip interlocks or FAULT indicator after making all connections called for on the SYSTEM INSTALLATION drawing supplied.

Set or verify the settings of the interlock enable/disable switches in the control module by:

- removing the rear screen and removing the module's top cover. (This may not be possible due to installation of optional instruments).

OR

- Remove the module by removing (4) front panel screws, unplugging the rear ribbon cables; then remove the top cover.

The LOGIC/MODULATOR is one large circuit board and contains two banks of DIP switches and several "suitcase" shaped jumpers. The circuit board is silkscreened with legends identifing these switches and jumpers.

The normal settings are:

SN1	-1	-2	-3	-4	-5	-6	-7	-8
	on	on	on	on	on	on	on	on
SN2	-1	-2	-3	-4	-5	-6	-7	-8
	on	on	on	on	on	on	off	off

NOTE

If option USQ-101 is installed set switch SN2-5 to "on". If no interlock is connected to TB5-5 & -6, a jumper must be added across TB5-5 & -6 or SN2-7 set to "off".

The individual "suitcase" jumpers are defined and shipped setup as:

X1	Install for input signal referenced to ground	INSTALLED
X2	Select trip polarity of Aux.1, [install for trip on lo level]	REMOVED
X3	Install to disable Aux.5	INSTALLED
X4	Connects common to chassis	INSTALLED

Additionally, there are the following "cut-trace" jumper options which may be setup at this time:

X5 Cut trace and install a 10 mfd or larger capacitor (50 V, non-polarized) if ac input signal coupling is needed.

X6 Substitute jumper for the standard "alarm silence" switch if silencing the audible alarm is not desired.

The function of each switch is listed in Table 2-2 following

CAUTION

These interlocks are provided to trip the amplifier off line in the event of an internal or external malfunction. System damage may result if a required interlock is disabled. Change the switches in Table 2-2 only for servicing or if you are changing the system configuration.

Switch	Trip Function (enabled = on)
SN1-1	Low voltage power supply
" -2	Line under voltage
" -3	Line over voltage
" -4	Phase loss (excess ripple)
" -5	Aux.4 (ext.field/hyd.press.)
" -6	Aux.3 (shaker overtemp)
" -7	Aux.2 (shaker overtravel)
" -8	Aux.1 (shaker air flow)
SN2-1	Isolated external interlock
" -2	Aux.5 (user defined)
" -3	Amplifier over current
" -4	Amplifier over voltage
" -5	Remote controller (USQ-101)
" -6	Polarity of Aux.4 trip,low = on
" -7	" " Aux.3 trip,low = on
" -8	" " Aux.2 trip,low = on

Table 2-2

CONTROL MODULE SWITCH DEFINITIONS

Re-install the LOGIC/MODULATOR module, plug in all ribbon cables (all pin one's are to the right as viewed from the rear).

2.6.5 Setup for Blower Remote or Local Control

Control module #712564 has no shaker cooling control switch. If the blower is to be controlled remotely, remove the jumper on TB5-18 to TB5-19 and install wires to the remote control contact to these same terminals.

CAUTION - THIS IS A 110 V ac CIRCUIT.

Unless ordered with an optional system controller, the unit will be shipped with the jumper in place between TB5-18 & 19.

If control module #712729 is used, the front panel switch is used to control the shaker cooling. No jumper should be on TB5-18 to TB5-19. For remote control operation with the USQ-101, set this switch to "OFF" or "(REMOTE)".

2.6.6 Check Blower Rotation

Check the rotation direction of the shaker blower. Turn the GAIN control to the CCW reset position (detent)

and turn on the main circuit breaker; the blower should start immediately. Turn off the amplifier power and check the blower's direction as it coasts to a stop. If rotation is incorrect, exchange any two wires to the three phase motor either at K2 in the amplifier or in the motor connection box.

2.6.7 Check Front Panels & Fans

With the gain switch in the 'reset' (detent) position; re-energize the amplifier. Check that only the front panel indicators marked "POWER" & "READY" are on and that all fans for the power modules are operating. No indicators marked "service" should be on on any of the power modules; if so, there are one or more blown fuses in any module with one of these indicators lit. The system is still operational, but will not be able to operate at full drive power.

De-energize the amplifier.

2.6.8 Low Level Functionality Test

Reconnect the shaker field connector that was temporarily disconnected in Step 2.6.1. Re-energize the Amplifier/Instrumentation System and connect the DRIVE SIGNAL and instrumentation as required by a typical test (this may be a bare table test; as long as there is a feed back accelerometer attached to the shaker table). Apply a low level signal to the MODULATOR's rear BNC jack (J5) and increase the amplifier gain to observe a response from the shaker.

THIS COMPLETES THE FUNCTIONAL SETUP AND CHECKOUT OF THE AMPLIFIER.

2.6.9 Adjustments

There are NO adjustments whatever in the POWER MODULES.

The CONTROL MODULE has four (4) front panel adjustments that may be set at this time. All are factory set to nominal values. These are:

OVERLOAD	@	(value of subsection 7.1.5)
OVERVOLTAGE	@	80 Volts ac
OVER DRIVE	@	72 Volts ac
OUTPUT OFFSET	@	< ± mVolt dc

The OVERDRIVE adjustment may be set at any value desired

since this only causes the front panel OVERDRIVE warning light to illuminate.

Great care should be used in re-adjusting the OUTPUT OFFSET; this controls the dc offset to the shaker. If an output matching transformer is used between the amplifier and the shaker, this offset control must be set as close to zero as possible. To prevent saturation of any output transformer.

If it is felt necessary to re-adjust the OVERLOAD, OVERVOLTAGE or OUTPUT OFFSET, refer to Section 7 of this manual for CALIBRATION and ADJUSTMENT.

SECTION 3
OPERATION

3.1 Local Operator Control Panel

The DMA amplifier may be operated at full rated power from dc (if dc coupling is used throughout the drive signal chain) to 2000 Hz and linearly derated to one half output power at 4000 Hz. Operation is through the local operator's panel on the LOGIC module or remotely through connector J2 on the rear of the LOGIC module. This section covers the local control operation only. See Sub-Section 4.8 for remote control operation. There are five indicators, four adjustments, an alarm silence switch and one gain control with a combined reset switch on the operator's control panel.

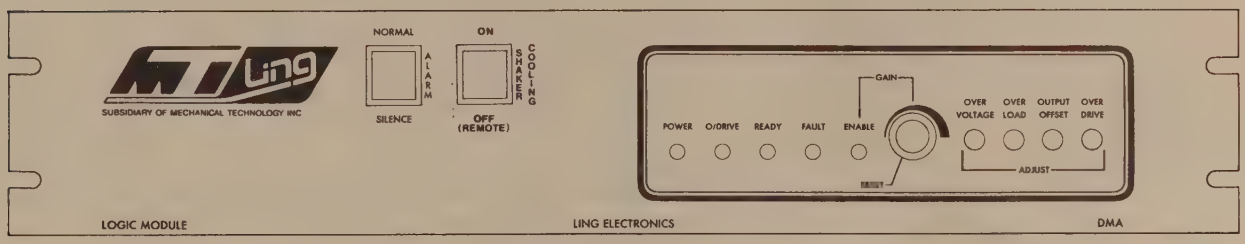

Figure 3-1

LOCAL OPERATOR CONTROL PANEL

GAIN CONTROL

This knob sets the gain of the amplifier. Zero gain is at the 'reset' detent position; maximum gain is at full CW. Faults may be cleared by turning this control to the 'reset' detent position, if the fault condition has cleared.

Maximum voltage gain of the amplifier is 60X (36 dB).

Maximum power gain of the amplifier (4 modules installed) is approximately 82 dB.

3.1 Local Operator Control Panel (cont)

ALARM SILENCE	Setting this switch to the "SILENCE" position mutes the internal audible alarm which operates whenever a fault condition exists. An LED on the switch reminds that the switch is in the "SILENCE" position. This switch does NOT disable the fault circuits.
SHAKER COOLING	This switch is connected directly to TB5-18 and TB5-19 (110 Volt ac circuit) to allow control of either the built-in blower contactor or optionally a remote shaker cooling unit. Set this switch to "OFF" or "(REMOTE)" when used with option USQ-101.
OVERDRIVE ADJ.	This adjustment is set as desired to provide a warning indicator to the operator that a voltage level has been or is about to be exceeded. This is usually set to cause the OVERDRIVE indicator on the front panel to illuminate just before clipping occurs on the output or just prior to reaching the overvoltage trip point.
OVERVOLTAGE ADJ.	This adjustment sets the voltage level at which the amplifier will trip 'off-line'. The FAULT indicator will be on when this condition occurs. Refer to the CALIBRATION Section 7.3 to set this level.
OVERLOAD ADJ.	This adjustment sets the average current level at which the amplifier will trip 'off-line'. The FAULT indicator will be on when this condition occurs. Refer to the CALIBRATION Section 7.4 to set this level.
OUTPUT OFFSET ADJ.	This adjustment sets the dc component in the output. Refer to the CALIBRATION Section 7.2 to set this level.

Indicators-

POWER	Illuminates to indicate basic functionality of the power supply for the Control Module and Modulator.

OVERDRIVE — Illuminates at the drive voltage level set by the OVERDRIVE adjustment pot on the front panel; usually set just below clipping or just below the overvoltage trip level.

READY — Illuminates when no fault condition exists; extinguishes approximately 0.5 sec after a fault, allowing time to drive the output to zero before it is gated to a high impedance off condition.

FAULT — Illuminates as a general problem indicator. There are (13) possible functions that can trip the amplifier off-line to this fault condition.

These are:

1. LOW VOLTAGE POWER SUPPLY, the ± 12 Volt supplies are out of spec.
2. UNDERVOLTAGE, main rail voltage is low.
3. OVERVOLTAGE, main rail voltage is high.
4. PHASE LOSS, there is excess ripple on the main power supply rails.
5. OVERCURRENT, the output current set point has been exceeded.
6. OVERVOLTAGE, the output voltage set point has been exceeded.
7. Aux.#1, user definable trip input
8. Aux.#2, user definable trip input
9. Aux.#3, user definable trip input
10. Aux.#4, user definable trip input
* 11. Aux.#5, user definable trip input (trip polarity = low only)
* (accessible only thru J2, normally used by the USQ-101 option)
12. EXT., user definable trip input (this input is optically isolated)
13. REMOTE Trip, active low available at J2 only, this trip is not latched.

ENABLE — Illuminates when the gain switch is NOT in its 'off' or reset position i.e. the amplifier is able to drive it's load.

Normal operation of this amplifier is in a system driving a shaker and incorporating a controlled signal source which is servoed from a feedback accelerometer signal from the shake table as indicated in Figure 3-2. Refer to the specific installation drawings supplied with your system.

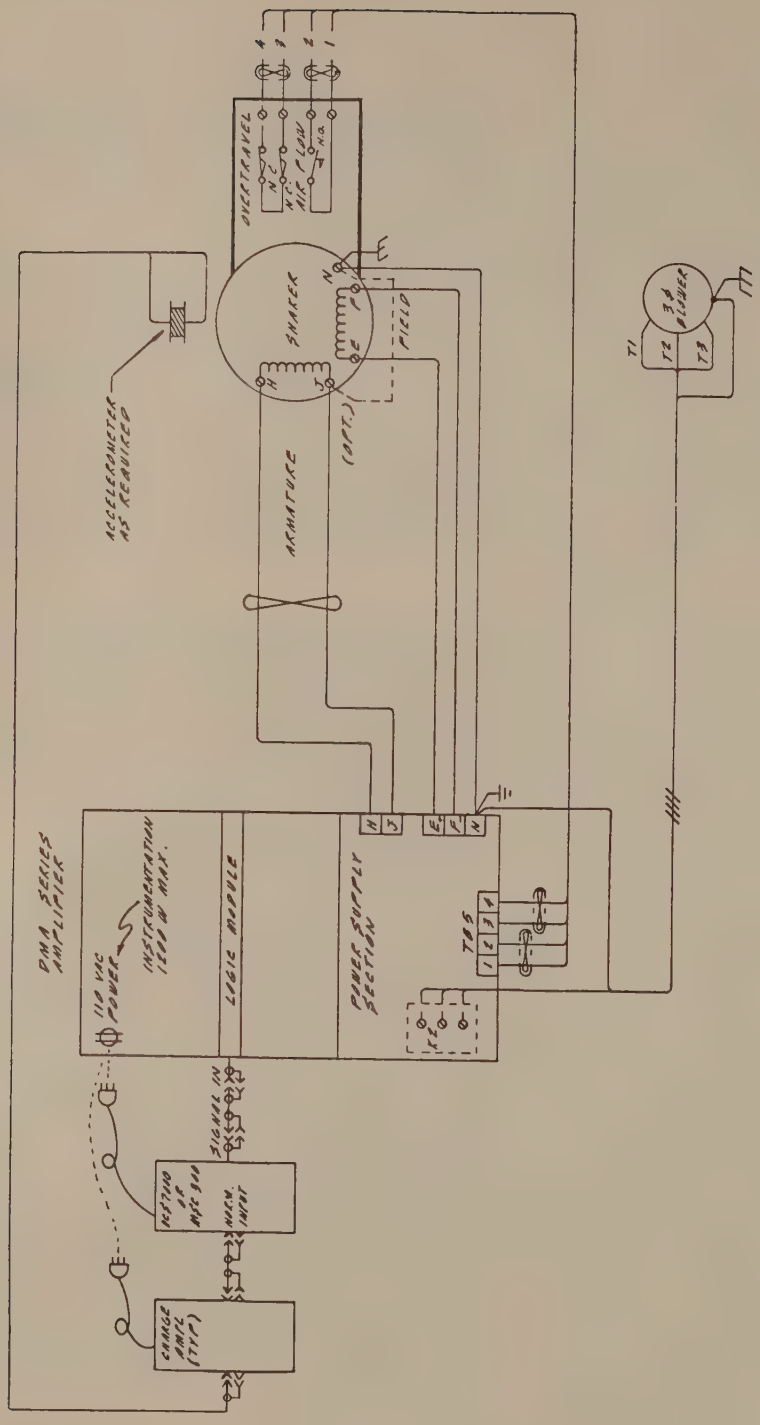

Figure 3-2

STANDARD SYSTEM DIAGRAM

3.2 INITIAL TURN-ON

To turn on the system:

1. Energize the power feed to the amplifier and turn on the main circuit breaker.

2. Set up the control instrumentation required to control the test.

3. Start the drive signal source and advance the amplifier's gain control as required to allow the controller enough loop gain to capture and servo the system.

3.2.1 Normal Operating Condition Indicators

It is recommended to have the GAIN control turned down to the 'reset' position when powering up the system. At this time, the only front panel indicators that should be on are:

POWER (READY)*

* If the logic card is set to be gated off when in reset, then the ready light will not be on until the Gain Control is turned up and the enable light also comes on.

If the amplifier is brought up with the gain control enabled or if the amplifier trips 'off-line' during a test the indicators that should be on are:

POWER FAULT ENABLE

This is normal, reset the amplifier by turning the GAIN control to the reset position or allow the optional external controller (USQ-101) to reset the system. If the offending trip condition has not been cleared, the FAULT light will not go out and the front panel will indicate:

POWER FAULT

With the system delivering power to a load or waiting to drive, the indicators illuminated will be:

POWER READY ENABLE

3.3 System Low G Level Operation

To operate at system acceleration levels below approximately 1 g, drive signal/instrumentation ground loops must not exist and the amplifier should be operated at the highest possible signal to noise ratios. The recommended system changes are:

1. Addition of a drive signal input audio isolation transformer to preclude instrumentation ground loops and provide increased input nois e isolation. Use of the input isolation transformer will limit low frequency operation to 10 Hz. High frequency operation will be unaffected to 4 kHz. Without this transformer, the amplifier is direct coupled and may be operated to D.C.

2. Addition of HI/LO Field Select Panel Option FSP-125 to select either `HI' shaker field for normal operation at full rated force or `LO' field for low g operation at reduced force levels.

3. All amplifier current limit, current trip, voltage trip and D.C. offset settings are as normally set.

4. Operate the accelerometer servo at 100 mv/g, if possible

3.3.1 OPERATION

Normal DMAX amplifier operation with option FSP-125 requires energizing the main circuit breaker of the amplifier which will start the shaker cooling blower and satisfy its internal air flow switch. When the air flow is proper, a 110 vac output interlock will be satisfied from the control module, causing 110 vac power for the field contactor to appear on TB5-17. This voltage is feed to the Field Select Panel, FSP-125. The operator must then select either `HI' field or `LO' field by pressing the appropriate pushbutton will illuminate indicating the field level selected.

NOTE

THE SYSTEM DOES NOT DEFAULT TO ANY FIELD SETTING. THE FIELD WILL REMAIN OFF UNTIL SELECTED BY THE SYSTEM OPERATOR. NO FIELD SELECTED WILL ULTIMATELY RESULT IN THE AMPLIFIER `TRIPPING' OFF-LINE DUE TO AMPLIFIER OVERCURRENT.

3.3.2 HI/LO FIELD SELECTION

Select `HI' field for normal, full force shaker operation. Select `LO' field for low acceleration (`g') level) or low noise operation. Selecting `LO' field operation causes the shaker to operate at a lower force-current ratio which causes the servo'ing loop controller to operate the amplifier at higher drive levels with consequently better signal-to-noise ratios. To reselect field levels, the amplifier must be powered down and back up again then select the new field level. The system purposely will not allow the field levels to be changed while the amplifier is on.

3.3.3 SYSTEM ADJUSTMENTS

For most fixtures with resonant modes, to maintain controllability the amplifier gain must not be advanced too far. Allow only enough gain to prevent the servo'ing unit's compressor circuits from going into full compression when driving at a system resonant peak. Additional, tuning of the servo's compression rate control, compression rate limit and charge amplifier filter may be necessary for low signal operation.

3.3.4 BODY & ARMATURE ISOLATION SYSTEMS

Insure that the shaker body air isolation system is pressurized to the correct level to center the LIN-E-AIR on the trunnion guide rods and that the lock-out bolts are removed. If the shaker is equipped with an internal load support system, adjust the air pressure to re-center the armature when supporting the test fixture and payload. Refer to the shaker Instruction Manual for further information on these adjustments. These measures will help assure vibration isolation for low g operation.

3.4 Operation With Switching Systems For Multiple Shakers

Amplifier operation with a switching system to select between two or more shakers requires that the amplifier NOT be delivering any voltage or curremt on its Field or Armature outputs when the selection contactors are operated, to prevent arcing damage to the contacts. Additionally, the softer suspension characteristics of the 520 Series shakers requires that the amplifier drive be held gated off until the field is fully established to prevent displacement of the armature during field build up if the amplifier output were enabled at the same time.

3.4.1 THEORY AND IMPLEMENTATION

When the amplifier is used in conjunction with a switcher added logic overrides the normal air flow switch (or other shaker cooling unit interlock) and turns off the field contactor control output. Normally, whenever control power is on and the shaker cooling interlock (AUX.2) is satisfied, the field control is energized. With a switcher option, added logic causes the field to be on only when the gain control is out of the RESET position and the air flow switch (or shaker cooling unit interlock) is satisfied.

Additionally, added logic is applied to prevent displacement of the armature during build up of the field. This is caused by the fact that the field is now required to be off for the benefit of the switcher (when the gain control is `down'; therefore when the gain control is turned up two actions happen; first the field is turned on and secondly (normally) the amplifier output is enabled resulting in the amplifier `driving' at zero output. The fact that between the armature and field one output is held constant and the other is varied, results in a net force on the armature which causes it to displace. A delay is added between the time that the gain is enabled (off reset) and the time that the amplifier drive is made ready.

3.4.2 OPERATION

The shaker cooling fault (AUX.2 trip) function will still operate normally if shaker cooling fails. No safety or fault diagnosis curcuits are affected.

Operation and perfomance of the system will not be impaired by these modifications. Control of the field will occur through either the local GAIN/RESET or the remote GAIN/RESET control of the RCP-104 option. When troubleshooting the field circuit, be certain that the gain control is advanced just off the detent. The field build-up for the 520 series takes several seconds. The amplifier's output drive is inhibited for several seconds after the gain control is advanced off of the reset position to allow time for the field to stabilize. The shaker should not be attempted to be driven until after the amplifier's `READY' light is on.

CAUTIONS

1. If no shaker is selected by the SSW-11X0 and the amplifier's gain control is enabled, causing the field to turn on, the field voltage measured at the amplifier's E & F terminals will have risen to the open circuit voltage level of approximately 1.4 times the normal loaded D.C. voltage. Avoid attempting to run the system in this mode, with no shaker effectively connected to the amplifier.

2. Do not advance the gain control significantly past the reset position detent until after the amplifier's "ready" light is on. Otherwise, if a drive signal were already present, the shaker would immediately start driving after the seven second gain enable delay, perhaps resulting in uncontrolled operation of the system.

All LING - DMA shaker switcher systems are further interlocked to the gain control to prevent either shaker disconnect or reselect unless the gain control is at RESET. The DISCONNECT button may be pressed when it is illuminated after the gain is turned to RESET and the preset field decay timer has timed out.

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SECTION 4
TECHNICAL INFORMATION

4.1 Specifications

Output	# of Power Modules Installed 1	2	3	4	5
kVA kW	4 4	8 8	12 11	16 11	16 note 1 11
RMS Amps	50	100	150	200	220
Peak Amps	110	220	330	440	550
RMS Volts	80	80	80	80	80 note 2

Note 1: Maximum power output is 11 kW at .68 power factor load. This is a transformer/ thermal limit for 3 to 5 module systems. (no transformer thermal limit exists for 1 and 2 module systems)

2: Thermally limited at full rated current, 105 Volts RMS sine equivalent available at reduced average current for random applications

Table 4-1

AMPLIFIER OUTPUT RATINGS

FREQUENCY RESPONSE (Sine Mode) (resistive load) - Full power from dc to 2000 Hz rolling off to -3dB at 4000 Hz. with 6dB/Octave slope. (see Appendix A)

CAUTION

OPERATION ABOVE 3 KHZ IS NOT GENERALLY RECOMMENDED DUE TO HEATING EFFECTS ON THE OUTPUT FILTERS.

DISTORTION	-	(at rated output) THD Less than: 0.5% from dc to 1000 Hz 1.0% from 1000 to 2000 Hz 2.0% from 2000 to 4000 Hz
HUM and NOISE	-	Greater than 60 dB below full output, with shorted input
DC STABILITY	-	Less than 0.05% of full output voltage with ± 10% change in line voltage.
INPUT DRIVE	-	1 Vrms into 10 kOhms for full output
ISOLATION	-	Output is isolated, may be grounded, "J" terminal only. See sub-section 2.4.3
SOFT START	-	0.1 sec from "OFF" to full power
SHUTDOWN	-	After a trip condition is detected, amplifier is ramp "commanded" to 0 Volts from full output within 10 ms. and clamped to disipate shaker energy for 1 sec. then output is gated to a high impedance off condition.
COOLING	-	70 CFM (.033m^3/s per module, 2750 BTU/hr/module (.806kW) rejected to the air (full output)
DC FIELD POWER	-	40 TO 450 Volts dc at 40 Amps (limited to 13 kW, total field power) Refer to Section 9.3
DIMENSIONS	-	HEIGHT 68 in (1.72m); WIDTH 22.25 in (.57m); DEPTH 25 in (.64m)
WEIGHT	-	Approximately 800 lb (363 kg) (with 5 POWER MODULES, excluding instrumentation)
INSTRUMENTATION SPACE AVAILABLE	-	22.75 inches (.58m) for options (with 5 power modules installed);

Note: This may be increased by 3.5 inches (89mm) for each power module not installed by use of a modified rear RFI screen panel from LING. Request modified part number 712772-X. Refer to Fig. 9-1 and Section 9.2 of this manual.

TEMPERATURE RANGE — Full power output may be obtained up to 40°C ambient. De-rate amplifier 1% per °C rise above 40°C.

INSTRUMENTATION POWER - 1200 Watts, 120 Volt ac single phase from an internally supplied plug strip

REMOTE CONTROL - Full capability for both remote control and monitoring (see Sections 4.8 and 9.0.1).

4.2 Standard System Ratings

Shaker Model	Amplifier DMA-5/X	# Sine Force	# Rand Force	Payload # Sine 10g	20g	30g
B385	DMA-5/1	650	440	52	20	9
	DMA-5/2	1500	850	135	60	35
	DMA-5/3	1500	1200	135	60	35
D390	DMA-5/1	1200	800	96	36	16
	DMA-5/2	2500	1700	225	100	58
	DMA-5/3	3000	2700	275	125	75
A395	DMA-5/2	3000	2000	235	85	35
	DMA-5/3	4500	3200	385	160	85
	DMA-5/4	6000	4400	555	255	155
	DMA-5/5	6000	5000	555	255	155
C/D395	DMA-5/2	3000	2000	175	26	--
	DMA-5/3	4500	3200	325	100	26
	DMA-5/4	6000	4400	475	175	75
	DMA-5/5	6000	5000	475	175	75

Table 4-2

STANDARD SYSTEM RATINGS

Note: DMA-5/x amplifier is 16 kVA mainframe with "x" POWER MODULES installed

The fifth power module of a DMA-5/5 supplies peak current capability for random applications only. Sine operation is limited by power supply capacity

4.3 System Theory Of Operation

4.3.1 General

The DMA Series of Amplifiers operate in a Class D mode, utilizing the principles of pulse-width modulation to amplify large amounts of power in a very efficient manner. By modulating a high-frequency signal and filtering out the unwanted switching frequencies a very pure output waveform is produced.

The system consists of a mainframe cabinet which houses unregulated power supplies for the power modules and the shaker field coil, the required number of power modules, and a logic module. There is also extra space available for user's instrumentation.

4.3.2 Power Modules

The system operation is most easily understood by starting with the basic power conversion that takes place in the power modules; please refer to Figure 4-1.

Each power module is basically a full-bridge configuration consisting of switches S1-S4, and a L-C filter L1, L2, and C1. dc power of approximately 170 Volts is brought into the module on P1 connector terminals 1 and 2.

Each half of the bridge (S1-S2 and S3-S4) switch at 56 kHz and with no signal input have a 50% duty cycle, in phase and thus no output voltage will appear across the output terminals (P1-3/P1-6 and P1-5/P1-7) any high-frequency noise will have been filtered out by the L-C filter.

If a sine-wave input signal is present, each half of the bridge will be modulated such that the duty-cycle varies at a sine-wave rate; in addition each side is driven out of phase so that an amplified sine wave appears across the output terminals.

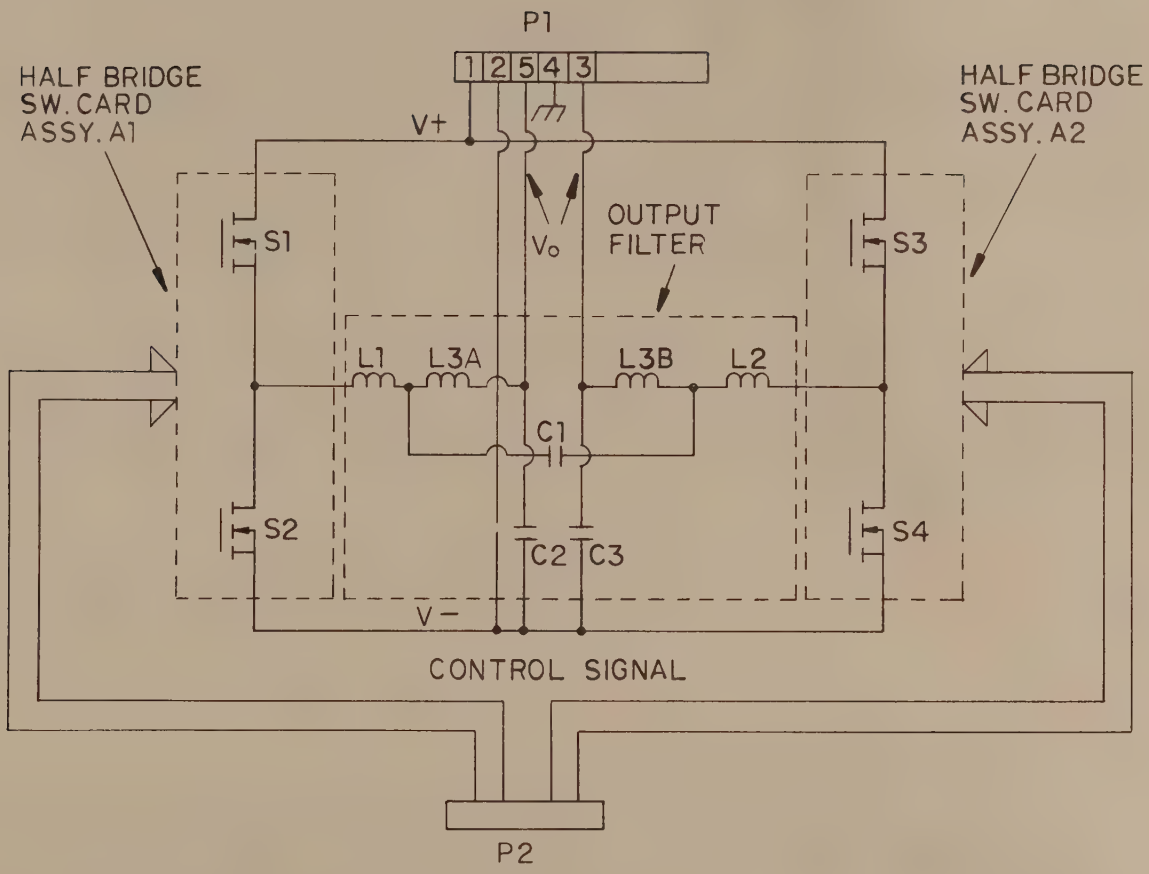


Figure 4-1

POWER MODULE BLOCK DIAGRAM

4.3.3 Logic Module

The logic module serves two functions:

1. To provide the pulse-width modulated drive signals for the power modules

2. To monitor all of the protective circuits of the system.

The modulator functions by amplifying the input signal and summing it with the system output feedback signal to generate an error signal; this signal is then compared to a precision triangle waveform to generate a pulse-width modulated logic signal to drive one half of the bridge in the power modules. The error signal is polarity inverted to generate the drive signal for the other half of the bridge.

If a system overcurrent condition is experienced, a clamp circuit will reduce the error signal amplitude until the current is within limits. The Drive Power Supply provides a high frequency square wave which each power module rectifies for module control and drive power.

The monitor circuits are comprised of six internal status conditions and six external interlocks. All 12 of these conditions must be within limits or the amplifier output will be shut down in a controlled manner.

4.4 Digital Amplifier Tutorial

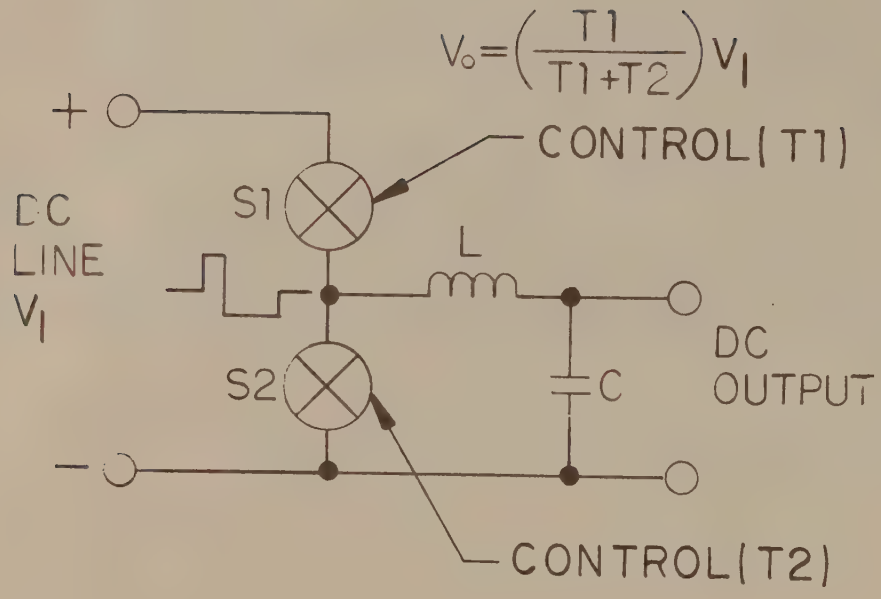
This section is included as an aid in understanding the theory of operation of a digital amplifier. Switching power supplies have gained wide acceptance in most types of modern electronic equipment due to their high efficiency and small size, in larger sizes they cost less than their linear counterparts. The same principles used in switching power supplies can be used to create a digital amplifier as described below.

The simplest form of dc power supply, the buck regulator, is depicted in Figure 4-2. Switches S1 and S2 are alternately switched on and off at a high rate, typically 20-100 kHz. The voltage at the junction of S1 and S2 will be a rectangular waveform with an average value equal to the duty cycle, or ratio of the time that S1 is on to the total period times the supply voltage. If this waveform is passed through a L-C filter with

sufficient attenuation to filter out all of the switching harmonics, then only the average or dc value will be present at the output terminals. Thus, by controlling the duty cycle, we can vary the output voltage from 0 to the input line voltage, and a feedback loop could automatically make adjustments to correct for ripple or line/load changes to produce a precise output.

If Figure 4-2 is modified to include a centertapped power supply with the centertap connected to ground, the output voltage can be varied from V- to V+ as the duty cycle is varied from 0 to 100%. If, instead of a fixed ratio, the duty cycle is varied back and forth from 0 to 100% at a sinusoidal rate, then the output voltage waveform will be a sinewave of 2 volts peak-to-peak. If the duty cycle was only varied from 40-60%, then the output sinewave would only be 0.4V peak-to-peak. The modulation frequency may be increased until the L-C filter will no longer pass that frequency.

The half bridge amplifier configuation of Figure 4-3 performs well, but high voltage devices must be used to achieve a high voltage output. The circuit of Figure 4-4, a full bridge configuration, will achieve the same output voltage, but with half of the power supply voltage. It also does not require a centertapped power supply to operate, and as long as the power supply is floating either output terminal may be grounded.

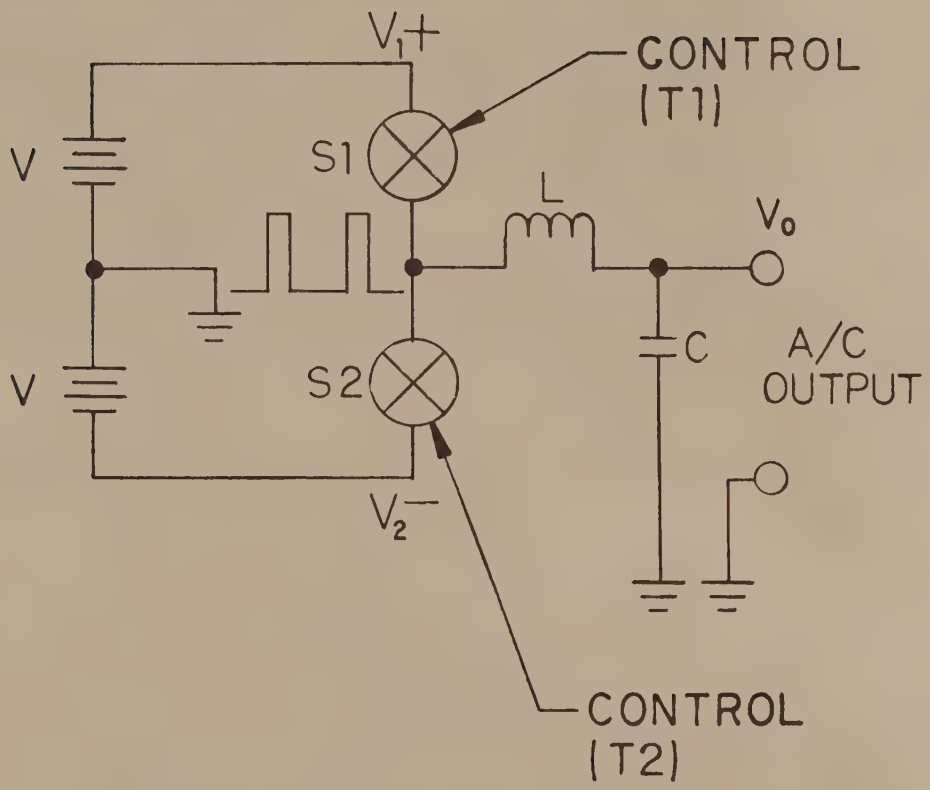


S1 and S2 are power switches with "on" time duty cycles of T1 and T2 respectively.

Figure 4-2

SWITCHMODE DC POWER SUPPLY

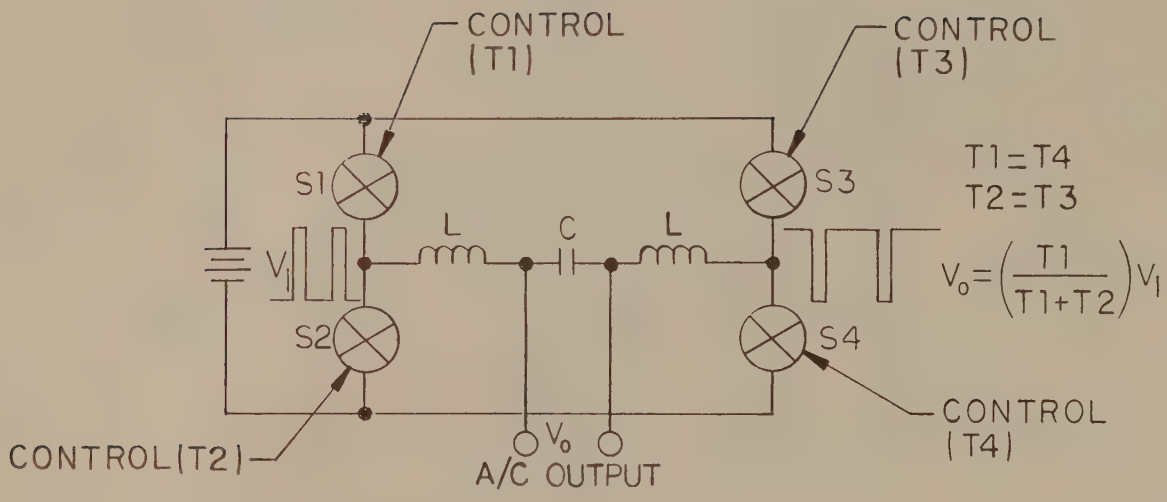
$$V_o = \left(\frac{T1-T2}{T1+T2}\right) V$$



S1 and S2 are power switches with "on" time duty cycles of T1 and T2 respectively.

Figure 4-3

HALF BRIDGE SWITCH MODE AMPLIFIER



S1, S2, S3 and S4 are power switches with "on" time duty cycles of T1, T2, T2, and T1 respectively.

Figure 4-4

FULL BRIDGE SWITCH MODE AMPLIFIER

4.5 Power Module Description

Each power module is a high-frequency pulse-width modulated power converter with a rating of about 4kVA. The topology is a full-bridge with the output filter contained inside the module to minimize EMI/RFI emissions. The switching frequency is 56 kHz and each half of the bridge is modulated out of phase, resulting in an effective 112 kHZ switching rate.

Each power module contains two (2) half bridge switch cards. The two quadrants on each card are switched 180 degrees out of phase.

The power that the module switches to the load is supplied from an unregulated dc supply of about 160 Volts through power connector P1. Local control power is derived independently from a 56 kHz square wave which is rectified and regulated at each quadrant switch. Switch command signals are optically isolated and routed via a ribbon cable. Ample heat sinking and two cooling fans insure safe thermal operation.

Internal faults that result in blown fuses to the FET switches on the switch cards light local neon lamps; light from these lamps is routed to the front panel via fiber optic cables to give a panel indication of the internal fault.

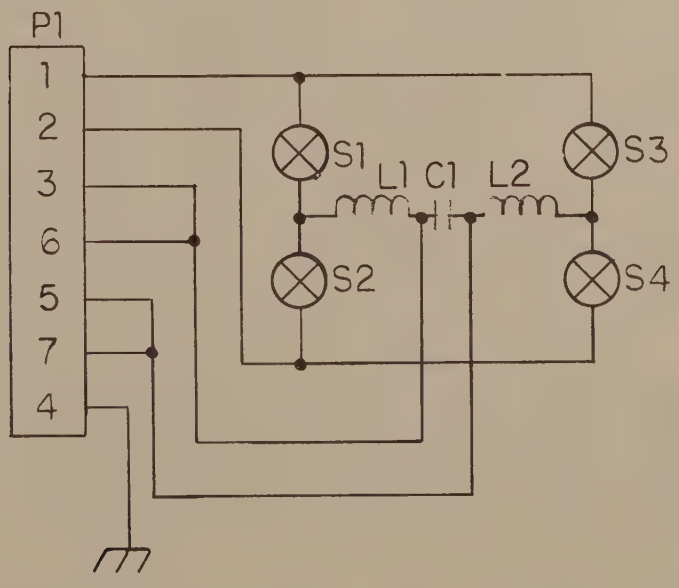


Figure 4-5

POWER MODULE, SIMPLIFIED DIAGRAM

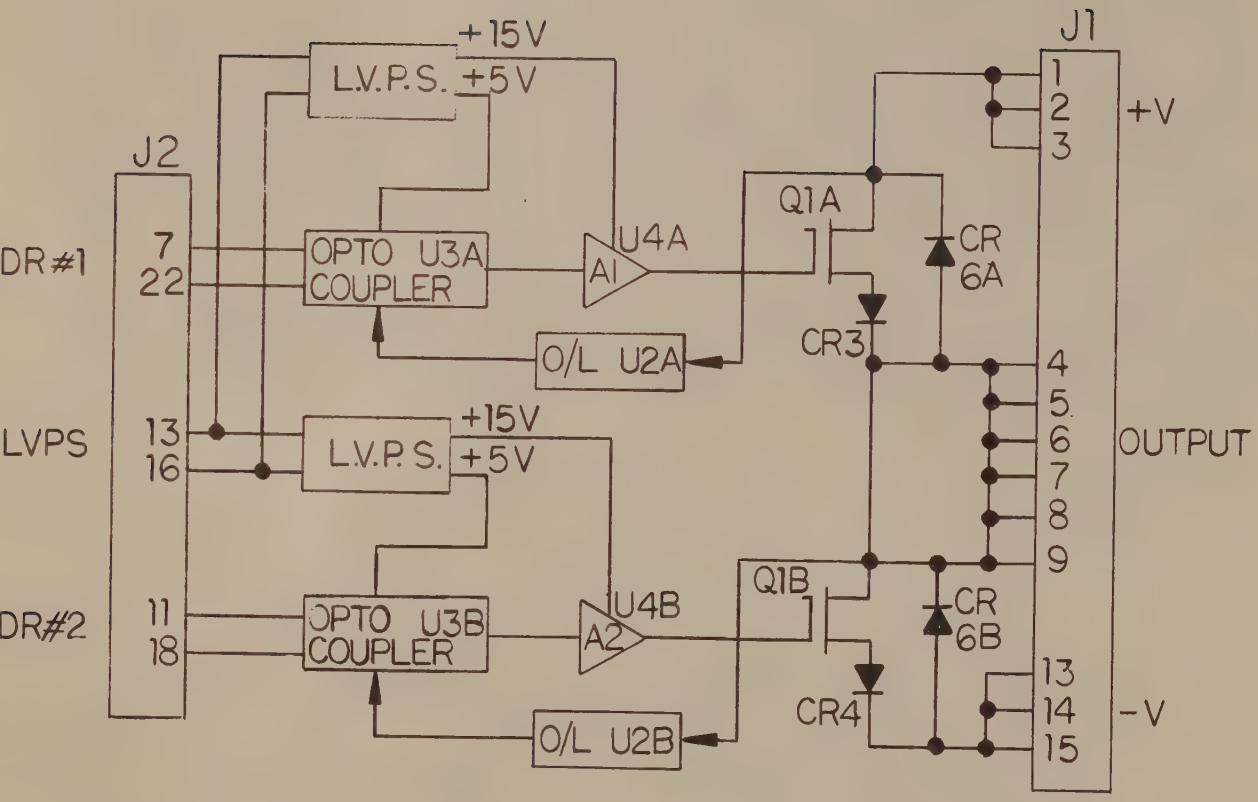


Figure 4-6

SWITCH CARD BLOCK DIAGRAM

4.5.1 Switch Card Circuitry

The switch card contains two identical high-speed high-power electronic switches wired in a half bridge configuration. Power is routed in and out on a 15-Pin Molex type connector and drive signals enter via a 26-Pin ribbon cable.

Each switch section is comprised of five power MOSFETS in parallel, which are individually fused so that if one should short it will clear itself from the circuit and the switch will continue operating at 80% capacity. A neon lamp will light in the case of a faulted transistor, and the light is routed to the front panel via a fiber optic cable. Each FET is protected from voltage transients with a Zener diode 'gate-to-source' and a MOV varistor 'drain-to-source'.

Refer to schematic #712549 and Fig. 4-6.

The drive signal that determines whether the switch is "on" or "off" is optically isolated with high-speed optocoupler U3. To achieve very fast switching times, a power driver (U4) is used and Q8-11 provide the high current required. The power consumed by the drive circuitry is supplied by a drive power supply. A 56 kHz square wave is isolated by T1, rectified by CR8-11 and filtered by C1-3; regulator U1 drops the voltage down to 5 Volts for the optocoupler.

If an overcurrent condition exists in a switch, it will manifest itself by an excessive voltage drop across the switch. When the voltage exceeds about 7 Volts, Q12 will turn on and trigger the current limit one-shot multivibrator U2 which inhibits the optocoupler and drive circuitry. This will repeatedly occur at a 10 kHz rate if the overcurrent condition persists.

4.5.2 Power Module Filter

The amplifier output power is generated by pulse-width modulating a 56 kHz square wave. To achieve a pure output at the desired frequency, the switching frequency and its harmonics must be filtered out; this is done by the power filter in each power module.

Switching noise has both differential and common-mode components. The first stage of the filter is a differential mode L-C made from L1, L2, and C1; this removes the bulk of the noise energy. The common mode energy is transferred

back into the power supply via common mode inductor L3 and capacitors C2 and C3. Any remaining noise on the output is removed by a second stage differential filter L4 and a capacitor, C7, located at the amplifier "H" & "J" output terminals.

4.6 Logic Module Description

4.6.1 Logic Module Modulator Circuitry

A simplified block diagram of the Logic Module Modulator Circuitry is depicted in Figure 4-7; the reference desiginators are the same as used on the card. This circuitry generates all of the drive signals for the power modules, allowing them to perform as a high performance power amplifier.

System timing is controlled by crystal oscillator U1A which runs at 3.58 MHz; this signal is divided down to 56 kHz by U2 to generate the switching frequency. The drive power requirements of the power modules are provided by a square wave power supply comprised of Q4, Q5, Q13 and Q14. The 56 kHz signal is also converted into a precision triangle by integrator U5.

The input signal enters on BNC connector J5 and is controlled by gain pot R35 and amplified by U14B. The amplifier output voltage feedback is scaled down to signal levels by feedback amplifier U6. These signals are summed by the error amplifier U4B with sufficient gain to insure a low distortion output waveform.

The system output current is sensed by a Hall effect sensor in the mainframe and transmitted to the logic card via J1. This low level signal is amplified by U13, and if it exceeds a threshold set by the system current limit adjustment trimpot R162, it will clamp the error voltage via U8.

The error voltage is compared against the triangle by comparator U9, which creates the pulse-width modulated drive for one half of the power modules. The error signal is inverted in polarity by U7 and also compared against the triangle by U10 to create the drive for the other half of the power modules. Modulation limits are placed on the drive signals by gate U31; U11 inserts a dead time into the switching to prevent one switch from turning on before its mate has turned off. These signals are buffered by power drives U12 and U32 and control the switching of all of the power modules.

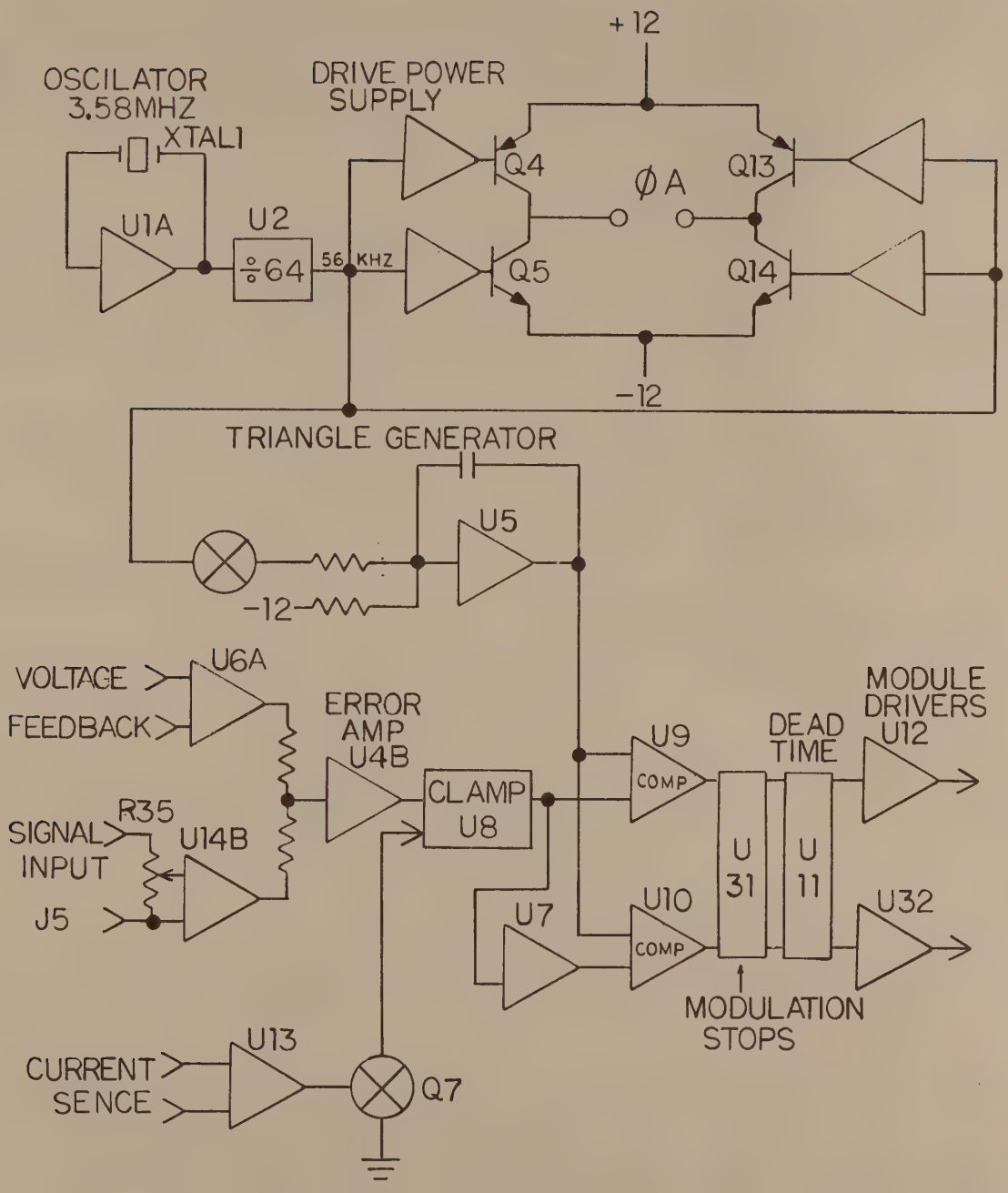


Figure 4-7

MODULATOR BLOCK DIAGRAM

4.6.2 Interlock/Protection Circuitry

A simplified block diagram of the interlock and protective circuitry is depicted in Figure 8; the reference designators are the same as used on the card itself. This circuitry provides the following functions:

A) AUX 1 THROUGH
AUX 4 Interlocks - four separate interlocks from external equipment, the polarity of each being individually settable by switch S1 and exclusive OR gate U23. NOTE: AUX 1 is wired to field control relay K1 and would normally be used with the cooling sensor.

B) AUX 5 Interlock
Similar to AUX 1 - 4, but not polarity selectable; may be disabled by jumper X3.

C) EXT CONTROL
An optically isolated external fault input. This input requires 12 Volts to enable.

D) OVERCURRENT
A load overcurrent trip is adjustable from 0 to rated current by front panel trimpot R72. It is normally set at slightly above rated current.

E) OVERVOLTAGE
An output overvoltage is adjustable from 0 to rated output voltage by front panel panel trimpot R71. It is normally set at slightly above rated output voltage. This may be used in sine mode as a velocity trip setpoint.

F) L.V.P.S. (Low Voltage Power Supply)
Monitor the internal +12V logic power supplies by U29 and faults if either decreases below 10 Volts.

G) HI LINE
The 3 phase ac input is monitored via the amplifier dc supply voltage, which is proportional to the line. Amplifier U27B translates the nominal 170 Volts to a lower level and U28A will generate a fault if the line goes above +10%; this will help prevent damage to the amplifier if the input is improperly wired.

H) LOW LINE
Similar to "G" above except amplifier U28B will generate a fault with a low line condition.

This is not a destructive condition and would merely limit output voltage capability.

I) PHASE LOSS
If one of three input phases is missing there will be excessive ripple on the amplifier dc supply. Differentiator U27 amplifies this ripple and will generate a fault if it is excessive.

J) POWER ON INDICATOR
A green LED that is on whenever ac power is present.

K) OVERDRIVE INDICATOR
A yellow LED that comes on whenever the output voltage is above a preset level, set by front panel trimpot R70. It is adjustable from 0 to rated output voltage and is independent of the overvoltage trip fault. It would normally be set below the fault to indicate approaching a fault condition.

L) READY
An "all is well" green LED that lights to indicate that there are no faults and that the system is operating properly.

M) FAULT CONDITION INDICATOR
A red LED that lights whenever a fault condition has triggered a fault If any of the 12 separate faults trip, they will be latched and generate an orderly shutdown procedure for the amplifier. The output will first be driven to zero Volts and held there for a fraction of a second by timer U21, and then the amplifier output will be turned off by driving the gate signal high. If a fault condition has been corrected, it can be reset by rotating the gain control knob fully CCW.

N) AMPLIFIER ENABLE
A green LED that lights whenever the gain control is advanced.

O) AUXILIARY CONNECTOR J2
All of the 12 faults and various other signals are present on a 34 Pin ribbon cable connector J2 to interface with optional equipment.

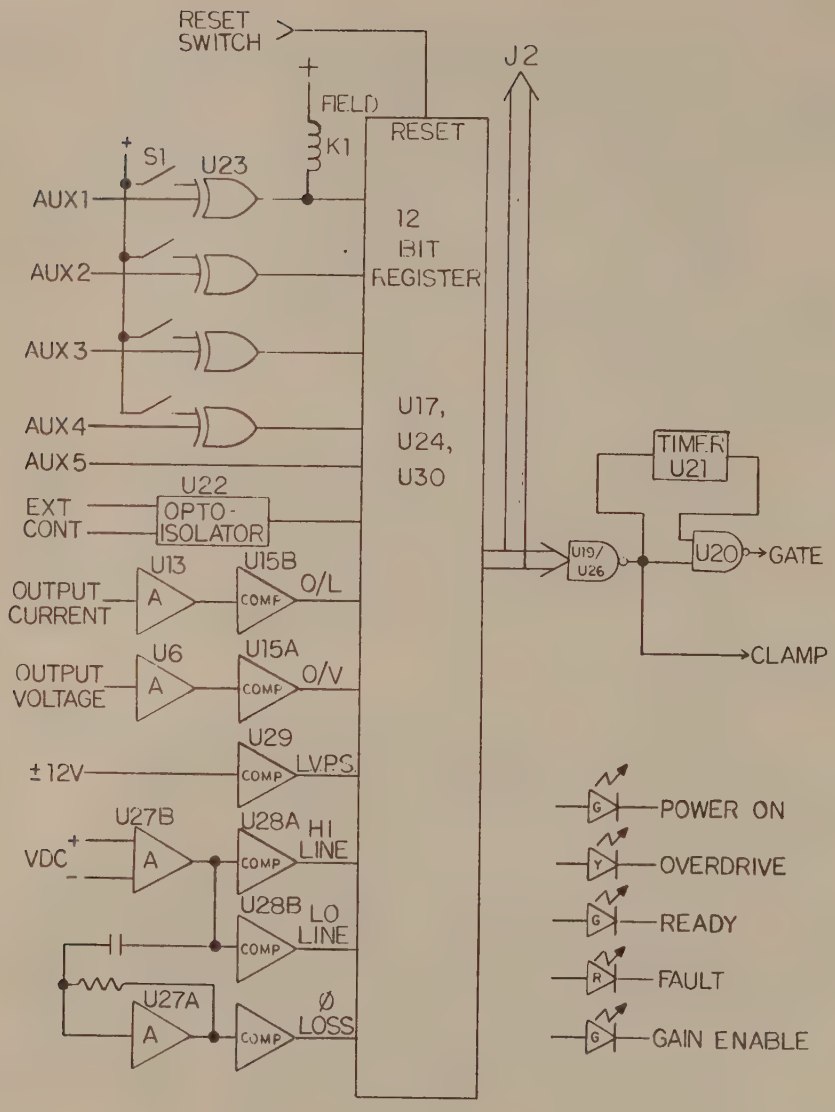


Figure 4-8

LOGIC INTERLOCK BLOCK DIAGRAM

4.7 MAINFRAME DESCRIPTION

The mainframe houses all of the sub-assembles of the amplifier. It also contains 22.75" (578mm) of blank panel space for instrumentation or options and a 115V power strip for powering options. Refer to Figure 4-9, System Block Diagram.

The bottom section of the cabinet contains both the power supply for the amplifier and the field power supply for the 385/390/395 shaker family; both are unregulated 3 phase FWB rectified supplies on isolated windings of power transformer 1.

A logic module provides safety and monitoring functions, and generates the drive signals for the power modules. It is powered from an internal power supply operating off a 115V auxiliary winding on the power transformer T1.

One to five power modules may be installed to provide the required power; they are identical, interchangeable and operate in parallel.

System output current is sensed by a Hall-effect current sensor and is used to limit maximum output current. This must be set for the number of modules that are installed. All customer connections are located in the lower rear of the cabinet on the terminal strips; these consist of: armature, field, blower, and interlocks.

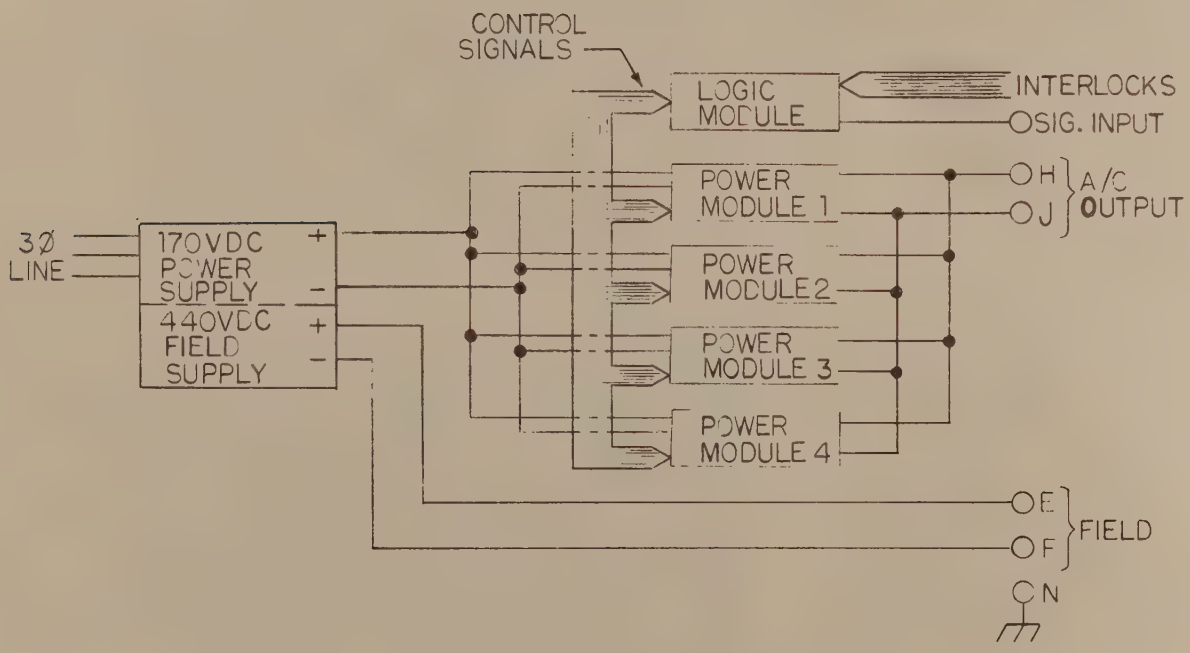


Figure 4-9

SYSTEM BLOCK DIAGRAM

4.8 Remote Control Capabilities

The DMA-5/X amplifiers have provision for complete remote control and for monitoring of operating parameters and fault conditions. Control points and functions are:

TB-5 on the power supply chassis (assy. 712539)

Terminal	Signal
TB5- 1	Air flow switch interlock
2	[ckt. common]
3	Shaker overtravel interlock
4	[ckt. common]
5	Shaker overtemp. interlock
6	[ckt. common]
7	Aux. trip interlock #4 (user defined)
8	System current sense (+) input (T2)
9	System current sense (-) input (T2)
10	+12 Volts dc (current limited to T2)
11	External (isolated) trip input (+)
12	External (isolated) trip input (-)
13	Gain is "up" switch closure
14	Gain is "up" switch closure
15	Armature power supply rail voltage (+)
16	Armature power supply rail voltage (-)
17	Field contactor control (110 Volt ac)
18	Blower (shaker) contactor control (110 Volts ac)
19	110 Volts ac [hi] from internal transformer
20	110 Volts ac [lo] from internal transformer

Note: The blower and field contactors are normally powered from the 110 Volt transformer winding built into the amplifier power supply. If these are to be remotely controlled, re-wire TB5-18, 19 & 20 as required. Please refer carefully to schematic #712546 and your specific warranty. If either of these contactors must be controlled from an independent source, consult LING engineering prior to making these connections to prevent any circuit backfeeds.

Table 4-3

INTERLOCK TERMINAL BLOCK DEFINITION

CAUTION

Both low voltage dc signals and 110 Volt ac power are present on TB5. Do not allow these voltages to become mixed.

The following connector pin definitions are for 12 Volt CMOS logic signals except pins 22 and 24 which are analog signals and pins 1,2,21,23,26-31 which are power supply connections. All are outputs except pins 16, 17 and 20 which are input controls.

This connector is intended for LING designed optional equipment. Please consult LING ELECTRONICS before using this connector.

J2 (center connector) on rear of logic module

Pin #	Signal	
J2-1	Ground [ckt. common]	
2	Ground [ckt. common]	
3	Reset-output monitor	hi = gain enabled
4	Output overvoltage trip	lo = tripped
5	Output overload trip	lo = tripped
6	Aux.#5 trip monitor	lo = tripped
7	External isolated trip	lo = tripped
8	Air flow trip monitor	lo = tripped
9	Shaker overtravel trip	lo = tripped
10	Shaker overtemp monitor	lo = tripped
11	Aux #4 trip monitor	lo = tripped
12	Phase loss trip monitor	lo = tripped
13	Line overvoltage monitor	lo = tripped
14	Line undervolt. monitor	lo = tripped
15	Low voltage power supply	lo = tripped
16	Remote trip INPUT	lo = trip
17	Aux #5 trip INPUT	lo = trip
18	Amplifier fault monitor	hi = fault
19	Gate drive to power switch modules	lo = gate off
20	Reset INPUT	lo = reset
21	Ground [ckt. common]	
22	Output voltage signal	± 10 Vdc analog
23	Ground [ckt. common]	
24	Output current signal	± 10 Vdc analog
25	(spare)	
26	+ 12 Volts dc	
27	+ 12 Volts dc	

J2 (center connector) on rear of logic module (continued)

Pin #	Signal
28	Ground [ckt. common]
29	Ground [ckt. common]
30	- 12 Volts dc
31	- 12 Volts dc
32	56 kHz square wave clock
33	(spare)
34	(spare)

Table 4-4

REMOTE CONTROL CONNECTOR - J2

SECTION 5
MAINTENANCE

5.1 GENERAL

It is recommended that operational checkouts, cleaning and inspections be performed on a scheduled basis. Initial recommendation is after 250 operating hours and 1000 hour intervals thereafter this should be adjusted as necessary to suit particular operating conditions.

WARNING

High voltages exist in all sections of this equipment. Any electrical servicing should be done by an experienced technician or electrician, especially if there is a need to troubleshoot the system in an energized condition.

5.2 GROUNDING

Normally, the signal input (low side), the amplifier output (J terminal) and the logic common are all at case and power ground. The armature and field power supplies are not grounded and must not be inadvertently grounded.

If the 'J' shaker lead is at ground potential, DO NOT connect a grounded scope probe to any of the circuits on any of the POWER MODULES (Assy. 712487).

Consult schematics prior to connecting instrumentation grounds; when in doubt, isolate line connected equipment with an isolation transformer.

NOTE

Use of a grounded scope probe anywhere on the amplifier is not recommended. Always use a line plug isolator.

5.3 Disassembly

The CONTROL MODULE and all POWER MODULES are removed from the front of the unit. However, access to the rear is required to unplug connectors. The POWER SUPPLY is removed from the rear, with access required from the front to disconnect wiring at the transformer and circuit breaker panel.

5.3.1 POWER MODULE Removal -

1. Disconnect power from the unit.
2. Remove the rear RFI screen.
3. Unplug the large circular power connector and the ribbon cable at the rear.
4. From the front, remove (4) mounting screws, (2) holding each side of the chassis to the mounting rails.
5. Slide the chassis out the front.
6. Remove (12) screws holding the top cover.
   If the top cover is installed with plastic snap clips, slide a flat blade screwdriver between the chassis and cover near each clip and pry up.
7. Reverse this procedure to re-install.

> **NOTE**
>
> All ribbon cables plug-in with the color stripe to the right as viewed from the rear.

5.3.2 SWITCH CARD Removal

1. Remove the power module and cover.
2. Disconnect (2) connectors in the center of the board, (1) ribbon cable and (1) power connector, lift straight out with a slight rocking motion. Protect the fragile pins of the ribbon cable connector after removal.
3. The circuit board is held in place with (9) snap mount plastic connectors, lift the board straight up, avoiding flexing it which may break solder joints.

5.3.3 Control Module Removal -

1. Disconnect power from the unit.
2. Remove the rear RFI screen.
3. Unplug all ribbon cables and (1) BNC signal input cable.

4. From the front, remove (4) mounting screws, (2) holding each side of the chassis to the cabinet mounting rails.
5. Slide the chassis out the front.
6. Remove (12) screws holding the top cover.
7. Reverse this procedure to re-install.

> **NOTE**
>
> All ribbon cables plug-in with the color stripe to the right as viewed from the rear.

5.3.4 CONTROL/MODULATOR CARD Removal

1. Remove the control module and cover.
2. Remove the front panel gain knob & panel lock nut.
3. Remove (6) screws holding the rear panel to the module chassis.
4. Unplug the power connector at the board.
5. Unplug any connector in the `options' socket J6.
6. Lift the circuit board off the (9) standoffs.

5.3.5 Power Supply Removal

1. Disconnect power from the unit.
2. Remove the (6) screws holding the rear sheet metal power supply cover. DO NOT remove the two (2) lower screws at this time; these hold the power supply chassis in place.
3. Disconnect all external cables (E & F, H & J,interlocks and blower).
4. Remove the lowest 2 or 3 power modules to gain access to the transformer compartment.
5. At the transformer, mark and disconnect all wires from the transformer to the power supply chassis.
6. Remove the (2) lowest chassis retaining screws and slide the power supply out the rear.
7. Reverse this procedure to re-install.

5.4 Cleaning, Exterior

Use water based cleaners only on the external finish, controls and indicators. Perform cleaning only with the power off. If excessive amounts of cleaner are sprayed, flushed or spilled into any chassis, do not re-energize the amplifier until the unit has been thoroughly dried out.

If the exterior fan grills need cleaning, remove the power module; the interior heatsinks will also need cleaning. Do not wash dirt from the grills into the power modules.

5.5 Cleaning, Interior (FANS, GRILLS & HEATSINKS)

Perform cleaning of the power module fans, grills and heatsinks on a scheduled basis to maintain thermal efficiency. Servicing cycles will vary depending upon the installation environment. Clean the air flow path in each power module:

- intake grill on the front of each module
- blades on each vane-axial fan
- heatsink fins and components on each board
- air exit louvers on each power module

Clean with a brush and shop vacuum or compressed air. Use solvents only to clean off accumulated oil films.

Inspect the power supply section, clean as necessary. Use compressed air to blow out the fins of the convection heatsink that mounts the bridge rectifier modules.

5.6 Inspection Of High Current Joints

Cleanliness and tightness of all high current joints is mandatory to prevent oxidation, overheating and FIRES.

Periodically, (within 250 operating hours after initial installation and yearly thereafter) inspect the following for signs of overheating such as discoloration or melted insulation:

- three phase power line filter
- main circuit breaker
- power transformer
- power supply section:
    - bridge rectifier modules
    - dc supply to power modules terminal block
    - field & armature output terminal blocks
    - capacitor filter bank buss bars
    - field & blower fuses and contactors

Do not remove any grease-like compound found on high current joints. This is there to prevent oxidation and improve conductivity.

5.7 Yearly Tests and Inspections

Once per year check the circuit breaker "trip test" if so equiped. This is accessed thru a hole below the circuit breaker handle.

It will be necessary to remove the dress panel (if so equiped). Insert a screwdriver blade into the access hole and press, the breaker handle should move to the center "trip" position.

The use of a shop vacuum is recommended to clean the transformer and power supply, use compressed air to blow accumulated dust from the windings.

At this time, also perform checks of Section 5.4 and record on Service Log Sheet.

5.8 Service Log

Date	Problem	Service Done	By

5.9 Spare Parts

Although this equipment is designed for the high reliability of digital electronics certain spare parts are recommended to be kept on hand in order to get maximum amplifier utilization and shorten the mean time to repair (MTTR).

Service Level	Recommended Quantity	Used on Assy. #	Item Description	LING P/N
1	1	712542	Logic Module	712729 or 712564
1	1	712542	Power Module	712487 or 713150
2	1	712729	Control Card	713346-1
2	2	712487	Switch Card	712551
2	1	712729	Power Supply (± 12 V)	82008-0043
3	1	712536	Diode Bridge (field)	82155-0057
3	1	712536	Diode Bridge (armature)	82155-0058
3	1	712538	Current Sensor	82307-0020
3	10	712551	Transistor	PS-11526
3	2	712551	Optocoupler	82454-0104
3	10	712551	Fuse (10 Amp)	82145-0199
3	10	712551	Fuse (0.25 Amp)	82145-0200
3	5	712551	MOV	82266-0612
3	2	712551	Capacitor	83001-3300k
3	1	712551	Diode	82110-0166
3	2	712487	Capacitor	83058-0205
3	2	712487	Capacitor	83058-0442K

Service level 3 parts are recommended and authorized only for personnel qualified to troubleshoot to the component level. Improper level 3 service may violate RFI Emissions Limits.

NOTE 1

If the system current sensor is changed, the current limiting circuits MUST be re-calibrated (See Section 7.1).

NOTE 2

If logic board 712566-100 is replaced by logic board 713346-100, the current limiting resistor feeding T2 on 712538, R4 must be removed, as it now will be on the new board. Re-calibration of the current limit MUST be done when replacing either the control logic card or the complete logic module.

SECTION 6
SUPPORT DOCUMENTATION

6.1 Drawings

The following LING drawings and parts lists are provided with this manual to assist in operation and servicing.

DRAWING	TITLE
712538 & PL	Assembly, Power Supply
712542 & PL	Assembly, Complete Amplifier
712543	Wiring Diagram, Power Module
712545	Logic Card Schematic
712546	Schematic, Mainframe DMA-5
712600	Schematic, Ribbon Cable Adapter
712710	Installation Drawing, DMA-5
713126	Schematic, Switch Card
713609	Amplifier Cabling Schematic

Table 6-1

DOCUMENTATION LISTING

6.2 Major Sub-Assemblies

When requesting parts or service on any assembly or sub-assembly, please refer to the list of assemblies:

[Assemblies containing active components only are listed, no sheet metal assemblies are included.]

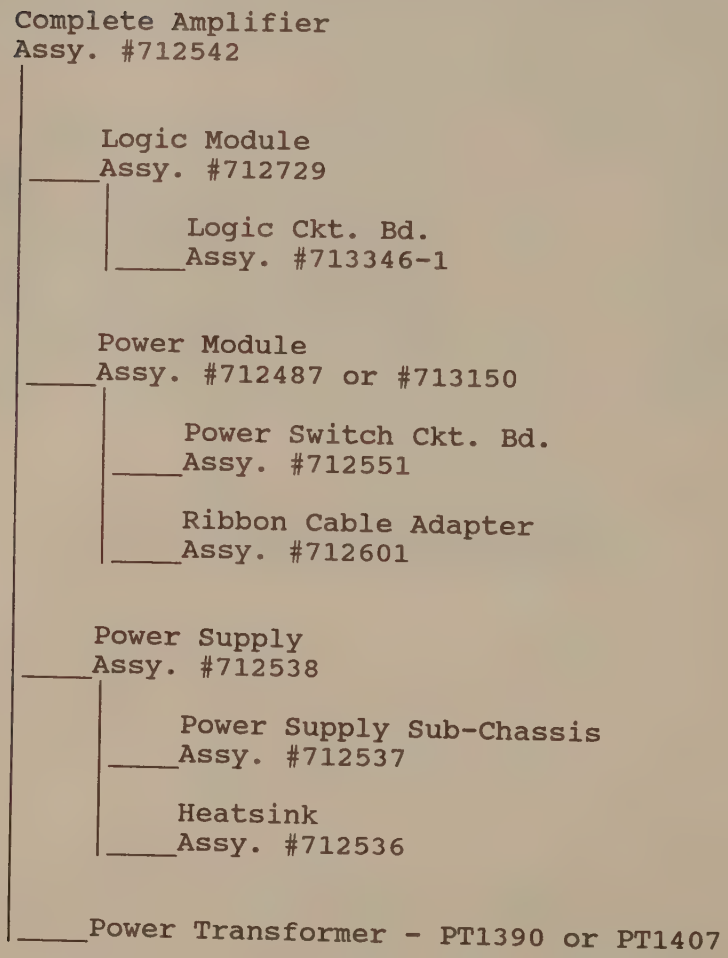


Table 6-2

SUB-ASSEMBLIES CHART

SECTION 7
CALIBRATIONS AND ADJUSTMENTS

7.1 Test equipment recommended:

- multimeter, FLUKE 8060A or equal
- oscilloscope, TEKTRONIX 547 or equal
- clamp-on ammeter, SIMPSON 154-2 or equal
- sine oscillator, H.P. 200CD or equal

7.1.1 Rated Current - Definition

The current rating of the DMA amplifier is 50 RMS Amps per power module (up to a DMA 5/4) based on 100% duty cycle and 70° F ambient air available to the power module fans. Higher RMS currents are possible until each power module has reached thermal equilibrium. Do not base test spectrum ratings or requirements on "cold" amplifier capabilities. An absolute maximum of 110 amps during random or shock spectra operation. See the operating curve of Appendix A4.

7.2 Current Limit

1. Gain access to the CONTROL/MODULATOR circuit board by either removing the cover with the module still in place or remove the module and re-connect the ribbon cables with the module outside the amplifier enclosure.
2. Turn GAIN control down (CCW).
3. Adjust R161 for 0 ± 20 mVolts dc at test point TP12.
4. Apply a 400 Hz 1 Volt peak signal to the input.
5. While monitoring the output current, increase the GAIN control until rated current for the amplifier is achieved. This is 50 RMS Amps times the number of POWER MODULES installed; up to four (4). The optional fifth POWER MODULE supplies peak current only for random testing applications.

eg. 1 = 50 Amps, 2 = 100 Amps
3 = 150 Amps, 4 = 200 Amps

CAUTION

If you have an optional five (5) module system DO NOT attempt to adjust the current limiting to 275 Amps, the power supply section CANNOT supply this level of RMS current. The fifth module will increase the sine RMS current capability 10% to 220 Amps.

6. While monitoring the output voltage with a scope, adjust R162 until clipping is observed on the output; then back off slightly.

7. Turn GAIN control down (CCW)

7.3 Output DC Offset

Use of the dc offset control for static load support is not recommended as this offset goes to zero when the amplifier is OFF or tripped. Also power required to support the load subtracts from that available to drive the test.

1. Turn GAIN control down (CCW).
2. With no signal input, monitor the output voltage, and adjust R120 (accessible through the front panel) for 0 ± 10 mV dc .
3. The dc offset will be most stable if one of the output terminals is grounded.

NOTE

The OVERLOAD and OVERVOLTAGE trip points are best set using a constant frequency and constant load. These are preset to trip respectively at 50 Amps X number of Power Modules installed and at 80 RMS Volts; these are maximum values and should be reset only for special test circumstances such as shock testing.
(See Sections 3 and 4.1)

7.4 Overvoltage

1. Turn GAIN control down (CCW).
2. Monitor the output voltage with an RMS voltmeter and drive the amplifier's input from a sine signal generator at 400 Hz.
3. Turn Gain control up and drive output to the level desired. Adjust R71 (accessible through the front panel) to produce a fault trip condition at the desired voltage level. If this is being done to provide a velocity limit shutdown, calculate this value from your shaker's performance graphs. This will generally be in the range of 1 Volt per inch per second (.04 Volts per mm per second).
4. The trip point circuits are slightly frequency sensitive. Refer to Appendix A5 for deviation factors if calibration is not done at 400 Hz.

7.5 Overload

This section requires the use of a variable resistive load able to dissipate the full power output of the amplifier.

1. Using the setup from 7.3 above, set the output at 60 Volts RMS and 400 Hertz; monitor output current, increase the LOAD (not GAIN) until rated current is reached.
2. Adjust R72 (CW) until the fault indicator lights.
3. Turn R72 (1) additional turn CW.
4. (Same as 7.4.4 above)

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SECTION 8
TROUBLESHOOTING

THIS IS NOT INTENDED TO BE A `SERVICE MANUAL'. COMPONENT FAILURES MAY OCCUR IN THE LIFE OF ANY ELECTRONIC PRODUCT. CONSIDER THE RECOMMENDED SPARE PARTS LIST TO ASSURE MAXIMUM PRODUCTION AVAILABILITY.

Troubleshooting the amplifier may be divided into two catagories:

1 the amplifier will not operate at all.

2 the system operates poorly.

It is important to separate system problems from amplifier problems. If system problems are suspected, remove instrumentation to temporarily reduce the system to the simplest operable configuration.

1. NO OPERATION (verify no output voltage)

   A. Check the obvious. Are proper voltages present at all checkpoints listed in Table 8-1?

   B. If output voltage is present when the amplifier is driven, but there is no shaker response; then the shaker armature may be open circuit (or unplugged).

   C. If the system has been working, review the latest "repair" done on or around the system.

   D. If the CONTROL MODULE indicates "power", "ready" and "enable" with the gain control advanced and an input signal applied, then the CONTROL MODULE is most likely defective. For continued FCC compliance, factory repair or replacement is recommended.

2. POOR OPERATION

   Note that during troubleshooting it is allowable to unplug any or all of the ribbon cable connectors to the power modules.

A. Insure that the drive signal source and feedback accelerometer are working and are calibrated.

B. Check the "service" indicators on the front of each POWER MODULE. If any of these are illuminated, the system's operation will be degraded from full performance. The system will still be operable but at lower performance levels. Have any modules in need of service repaired. Refer to Section 8.1.4

C. Verify all voltage checkpoints in Table 8-1.

D. If no conclusive problem is found, change the LOGIC MODULE (service level 1) or alternately change the CONTROL/MODULATOR circuit card (service level 2). See section 5.6 for spare parts and section 8.1.3 for disassembly and replacement.

8.1 Voltage Checkpoints

Use a quality VOM or DVM on the proper voltage range to check for the presence of the voltages listed. Consult the assembly drawing for the assembly listed for checkpoint locations. Amplifier "energized" means power applied through the main circuit breaker to the internal power transformer. The amplifier does not necessarily have to be gain "enabled" or driving a load.

#	Assy.	Ck. on	Voltage	Conditions
1	712538 power supply chassis	K2, line side	nominal line std. (480 Volts ac)	amplifier "energized"
2	712538	K2,load side (blower on)	"	K2 energized
3	712538	K1,line side	ac Volts L-L as selected (table 9-1)	amplifier energized
4	712538	K1,load side (field on)	"	amplifier & blower on (K2 energized)
5	712538	F7 to TB5-20 (control power)	110 Volts ac	amplifier energized
6	712538	C1,C3,C5 & C2,C4,C6 buss bars	165 Volts dc ± 10 V (arm.rails)	amplifier energized

8.1 Voltage Checkpoints (cont.)

7	712538	term. E & F (+) (-)	field V as selected (table 11)	K1 energized
8	712538	TB5-1 to 2	+12 Volts dc 0 Volts dc	air flow sw. open " " " closed

	Assy.#	Ck. on	Voltage	Conditions
9	712538	TB5-3 to 4	+12 Volts dc 0 Volts dc	overtravel sw. open " " closed
10	712538	TB5-5 to 6	+12 Volts dc 0 Volts dc	overtemp sw. open " " closed
11	712538	TB5-7 to 6	+12 Volts dc 0 Volts dc	user interlock open " " closed
12	712538	TB5-8 to 9	[system output current feedback] [this is a low level signal not] [readily measured with a meter]	
13	712538	TB5-10	+12 Volts dc	available from the lo voltage P.S.
14	712538	TB5-11 to 12	+12 Volts dc 0 Volts dc	ext.interlock open " " closed
15	712538	TB5-13 to 14	[this is an isolated contact from] [the gain/reset switch to be used] [to 'lockout' an external shaker] [station multiplexer or interlock] [with the optional RCP-102 remote] [control panel - voltages depend] [on external circuit use] [closed = gain enabled]	
16	712538	TB5-15 to 16	165 Volts dc	as Ck. #6 above
17	712538	TB5-17 to 20	120 Volts ac	shaker field on
18	712538	TB5-18 to 20	120 Volts ac	shaker blower on
19	712538	TB5-19 to 20	120 Volts ac	amplifier energized
20	712729	J4-1 to 2	120 Volts ac	amplifier energized
21	712729	J4-5 to 7	+12 Volts dc	" "
22	712729	J4-8 to 7	-12 Volts dc	" "
23	712551	TP3A to TP1A	+18 Volts dc	amplifier energized
24	712551	TP3B to TP1B	+18 Volts dc	amplifier energized

Table 8-1

VOLTAGE CHECKPOINTS

8.2 User Repairs

WARNING

Substitution of parts and repairs not specifically authorized under this heading may cause this amplifier to violate FCC noise limits. For continued FCC compliance, return to LING all modules not defined as user repairable under this section.

NOTE

NO USER REPAIRS ARE AUTHORIZED DURING THE WARRANTY PERIOD.

8.2.1 Fuse Replacement

The most common repair to be encountered will be fuse replacement. The chart in Table 8-2 is the complete complement of fuses used throughout the amplifier.

The fuses used on the POWER SWITCH CARD are "picofuses" and are similar in appearance to 1/4 Watt resistors. The 0.25 Amp are the most fragile; too much heat will destroy the internal fuse link. Similarly, great care must be used to remove the fuse from the circuit board without lifting pads or damaging the plated through hole. The SWITCH CARDS are made from 4 oz. copper and will require a minimum soldering iron wattage of 25 Watts.

8.2.1 Fuse Replacement (cont.)

Assembly	Designations	Rating	Mfr. P/N
Power Module Switch Card Assy.712551	F1,3,5,7,9 F2,4,6,8,10	10 A 0.25 A	Littlefuse 257010 251.250
Modulator Assy.713346-1	F1	10 A	Littlefuse 275010
Power Supply Field Blower Controls Assy.712538	 (3) F1-3 (3) F4-6 F7	 40 A 30 A 10 A	 KTK 40 FMN30 MDL10

Table 8-2

FUSE CHART

8.2.2 MODULATOR POWER SUPPLY

REPLACEMENT

1. Disconnect power and remove the LOGIC MODULE and cover.
2. Unplug the power supply cable to J4 and unbolt the power supply from the chassis.
3. Unsolder the harness from the power supply
4. Reverse this procedure to install the new assembly. Use heatsink compound between the surface of the new power supply and the chassis for best thermal operation.

ADJUSTMENT

The +12 Vdc and -12 Vdc may be adjusted to ± 5% of nominal by adjusting the small trimpot in the section of interest.

1. Gain access to the logic module thru its top cover as in Section 8.1.3.

2. Adjust trimpots while monitoring the voltage test points on the logic card.

3. Re-assemble and install.

8.2.3 Control/Modulator Card Replacement

1. Follow the instruction of Section 5.1.2 to remove the CONTROL/LOGIC chassis.
2. Remove the front panel of the CONTROL/LOGIC chassis.
3. Unplug the power supply connector from J4 and any options plugged into J6.
4. Remove and replace the circuit card.
5. Perform the current limit calibration for your unit's rated current per Section 7.1.
6. Re-assemble the chassis and install the module.

8.2.4 Power Module Repair

REPLACEMENT OF CIRCUIT CARDS

1. Remove the power module SWITCH CARD per Section 5.1.1
2. Disconnect P1, P2 and the two fiber optic cables from the circuit card.
3. Lift the board off its supports and replace.
4. Reverse these procedures to re-install.

REPAIRS TO THE SWITCH CARD

1. If the 'SERVICE' indicator is illuminated on the front of the POWER MODULE, one or more fuses are blown in that respective SWITCH CARD quadrant.

2. Remove the circuit card as outlined above and locate all open picofuses with an ohmmeter. This may be difficult if a power FET transistor is also shorted. Observe ohmmeter readings closely.

3. For each blown fuse there will likely be a failed power FET. Locate these and replace (each are in individual sockets). Also check associated components such as the MOV. Note that no insulating washers are used between the power FETs and the heatsink.

4. Reverse procedures to re-install.

SECTION 9
OPTIONS

The following options are available for use in conjunction with the DMA-5 Amplifier.

9.1 RCP-104 Remote Control Panel

This option allows the system to control and monitor the operation of the amplifier from a remote location (up to 200 feet (30.5m)).

Features:

- remote signal injection
- remote gain pot (the standard local gain control must be left preset at the maximum desired gain). If the "ACTIVE" light is not lit at the remote operator's panel, the local gain/reset switch is in the detent reset position and the system will not be able to operate.
- remote display of amplifier output performance (voltage and current) in either peak or RMS units.
- remote display of all monitored fault conditions.
- remote amplifier fault reset capability.
- remote control of shaker blower and field (field is energized automatically when air flow through the shaker is adequate.)

Please refer to the more complete manual supplied with this option for installation and operation.

9.2 USQ-101

This is a programmable controller, interfaced to the amplifier, instrumentation and an external environmental chamber. Its purpose is to help automate the test sequence and gain maximum utilization of the shaker and amplifier. Running the system under USQ-101 operation requires powering up the amplifier, turning the amplifier's gain switch away from the "RESET" position and pressing the RUN/STOP switch once or allowing a remote chamber controller to activate the RUN/STOP input #004. It is not necessary to reset the amplifier, the USQ will do this automatically at the right time.

Interfacing:	Inputs	Outputs
	Amp `fault'	Amp `trip' Aux.5
	Amp `enable'	Amp `reset'
	run/stop	start DCS-7000SR
		stop DCS-7000SR
	instrument fault	test complete
		Amp blower on
		reset instruments

Programmed Test Sequence:

STEP #1	Wait for the amplifier gain switch to be 'enabled' and a 'start' command to be received from the 'run/stop' input #004.
STEP #2	Output a 1 sec. instrumentation reset pulse on output #025.
STEP #3	Turn on the shaker blower.
STEP #4	Reset the amplifier, if an amplifier fault condition exists.
STEP #5	Start the DCS-7000SR with a 0.5 sec pulse on output #012.
STEP #6	Time the test if the 'automatic' input #002 is on, else wait for a 'stop' command from the 'run/stop' input #004.
STEP #7	Stop the DCS-7000SR with a 0.5 sec pulse on output #013.
-	Reset to step #1.

The test sequence is aborted if any of the following conditions are detected:

1. An instrumentation 'fault' occurs in either Step #5 or #6.
2. An amplifier fault occurs in step #6.
3. The gain switch is turned to the 'reset' position during step #6.
4. The auto/manual switch is changed from the `AUTO' position to the 'MANUAL' position.

Please refer to the more detailed documentation supplied with this option for more complete information on interfacing and program capabilities.

9.3 Field Expansion of Power Rating

It is possible to expand the power output capability of this amplifier in 4 kVA increments up to 16 kVA for the DMA-5. A fifth power module may be added to the DMA-5 to supply peak current capability for driving in random mode. Refer to Table 4-1.

The DMA-5 class amplifiers are shipped from the factory with all power harnesses and control ribbon cables necessary for later field upgrade within the same class shaker. For example, a system may have been originally purchased for driving an A395 shaker at 3200 lb-force (14.23kN) in random mode and now the requirement is for 4400 lb-force (19.57kN) random. This would require installing one (1) additional power module.

Procedure:

1. Remove power from the amplifier and allow 5 minutes for the power supply capacitors to bleed down.
2. Remove the rear RFI screen and the front blank off panel for the location that is to receive the new power module.
3. Remove any contact protectors on the power connector [P1] and logic connector [P2].
4. Slide the module into place and connect both rear connectors. (red stripes are always to the right)
5. Re-install the rear RFI screen and review Section 2.6 for setup and turn-on procedures prior to powering up the amplifier.

NOTE

The use of PM5 Power Modules does not increase the amplifier power rating even though they are rated at up to 5kVA each. The increase in rating is due to operation from higher supply voltages.

9.4 Adding Instruments

A total of 22.75 inches (578mm) of panel space is available in the DMA-5 mainframe for installed instrumentation above the amplifier section. Optional equipment may be installed in place of any blank panels. Please refer to the Instrumentation Worksheet, Figure 9-1, for the DMA-5 to assist in sizing and placing optional instruments.

It is NOT recommended to install instrumentation in the amplifier section, i.e. below the control module. Use only the upper half of the cabinet for options.

A 110 Volts ac plug strip is provided as standard in the upper rear of the instrumentation section. Power for instruments or optional equipment is limited to 1200 Watts.

If additional instrument space is needed and the amplifier does not have the maximum of (5) power modules, then an additional 3.5 inches (89mm) may be gained for each power module absent. This does require additional rear blank-off panels and a new, modified rear RFI screen panel available from LING. Request modified part number 712772-X.

CAUTION

For continued FCC compliance, do NOT run your amplifier without this RFI screen installed.

Adding instruments may affect interconnect cabling for existing equipment. All LING supplied instrumentation is supplied with all necessary cables, connectors and adapters.

9.5 Changing Shakers (Field tap re-select)

It is possible to change shaker types by reconnecting the field secondary taps on the main power transformer (T1) according to the following table:

PT-1390:

Tap Selection		Application	Field	Volts DC
Line to BR-1	Y Connect			
7-8-9	Fixed	395 shakers	full	440
10-11-12	"	390 shakers	full	190
13-14-15	"	385 shakers	full	100

Table 9-1A

FIELD TAP SELECTIONS

Pt-1407:

Tap Selection		Application	Field	Volts DC
Line to BR-1	Y Connect			
8	7	385 shakers	1/4	44
9	8	385 shakers	1/2	66
9	7	385 shakers	full	108
10	9	390 shakers	lo	126
10	8	390 shakers MB C10/C25	full lo	193
10	7	MB C10/C25	full	237
11	9	395 shakers	lo	340
11	8			405
11	7	395 shakers	full	450

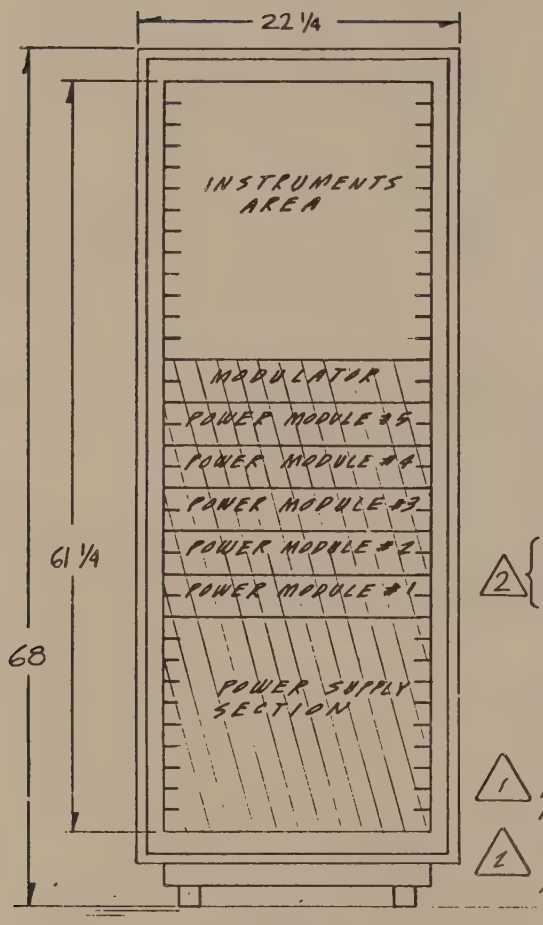
Table 9-1B

FIELD TAP SELECTIONS

This is most easily done by removing all POWER MODULES and the MODULATOR to gain working access to the transformer compartment through the top of the power supply section. Move the three ac wires to the selected field taps [phasing is not important]. Tighten all joints and re-insulate any unused transformer terminals.

The field connection possibilities of the PT-1390 cover only LING air cooled shakers. The PT-1407 transformer allows field voltages compatible with non-LING manufactured shakers as well as allowing reduced power field operation for either low `g' tests or reduced impact on LAB air conditioning systems.

Refer to Section 3.2 for system considerations when using Field Select Panel option FSP-125.



INSTRUMENT PANEL SPACE

MODEL	INCHES	INCREMENT OF 13/4" STD	INSTALLED (Y)
DCS-7000	12.25	7	
MSC-300	7.0	4	
TAP-100	3.5	2	
TAP-1000	3.5	2	
CO-101	3.5	2	
VM-100C	3.5	2	
VS-100B	3.5	2	
MXA-100	3.5	2	
RXY-107	10.5	6	
ANM-100	7.0	4	
USR-101	1.75	1	
OSR-101	5.25	3	
APS-106	3.5	2	
SCO-1000	7.0	4	
AGM-4000	5.25	3	
DDM-100	3.5	2	
TOTALS			

(2) USR-101 HAS TWO PARTS, OPERATORS PANEL 1 3/4 & CONTROLLER 5 1/4.

(1) STD. D.M.A.-5 HAS 22.75" OF INSTRUMENTATION SPACE (13 INCREMENTS)

Figure 9-2

INSTRUMENTATION WORKSHEET

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Appendix A PERFORMANCE CHARTS

Chart A2 is a plot of the frequency response of the DMA power modules at various load levels. The plots are for the amplifier alone into a resistive load using a swept sine signal source at constant amplitude.

Chart A3 is the gain/phase plot v.s. frequency for the DMA power module.

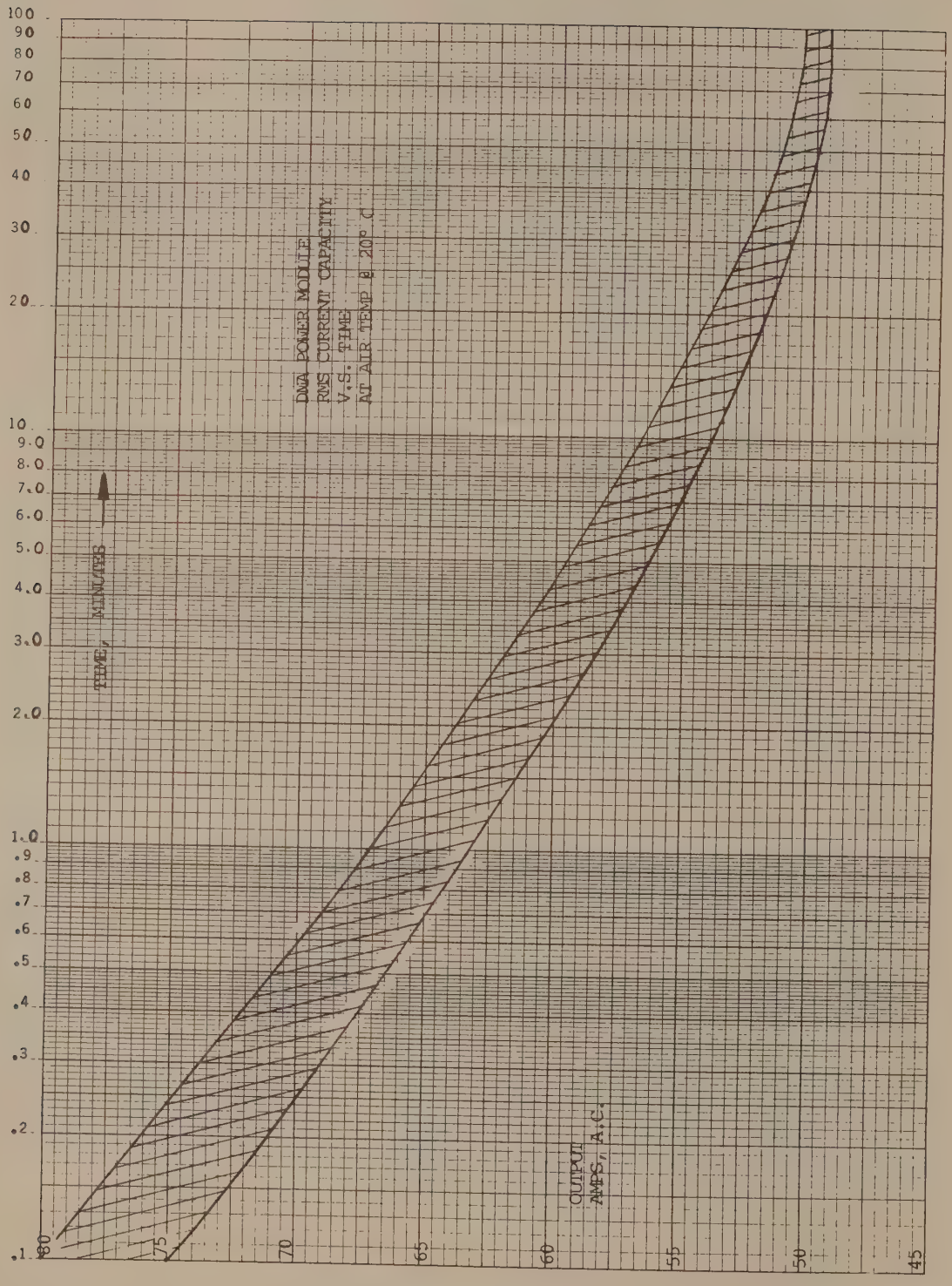
Shakers behave as dynamically active loads; at low frequencies V-I phase relationships will be capacitive in nature; at high frequencies the V-I phase relationships will be inductive. Any payloads being tested contribute to the dynamic load impedance. Thus the final system response characteristics will be a composite of the amplifier's response, its output filter and the instantaneous impedance contributed by the shaker and its payload.

Chart A4 plots the RMS output current/module versus operating time. For short duration testing or shock applications the chart may be used if the system current unit setting is relaxed. Persistent operation on this curve longer than 10 minutes will cause the power module to start selflimiting by periodically turning themselves off, resulting in a "tick" in the output.

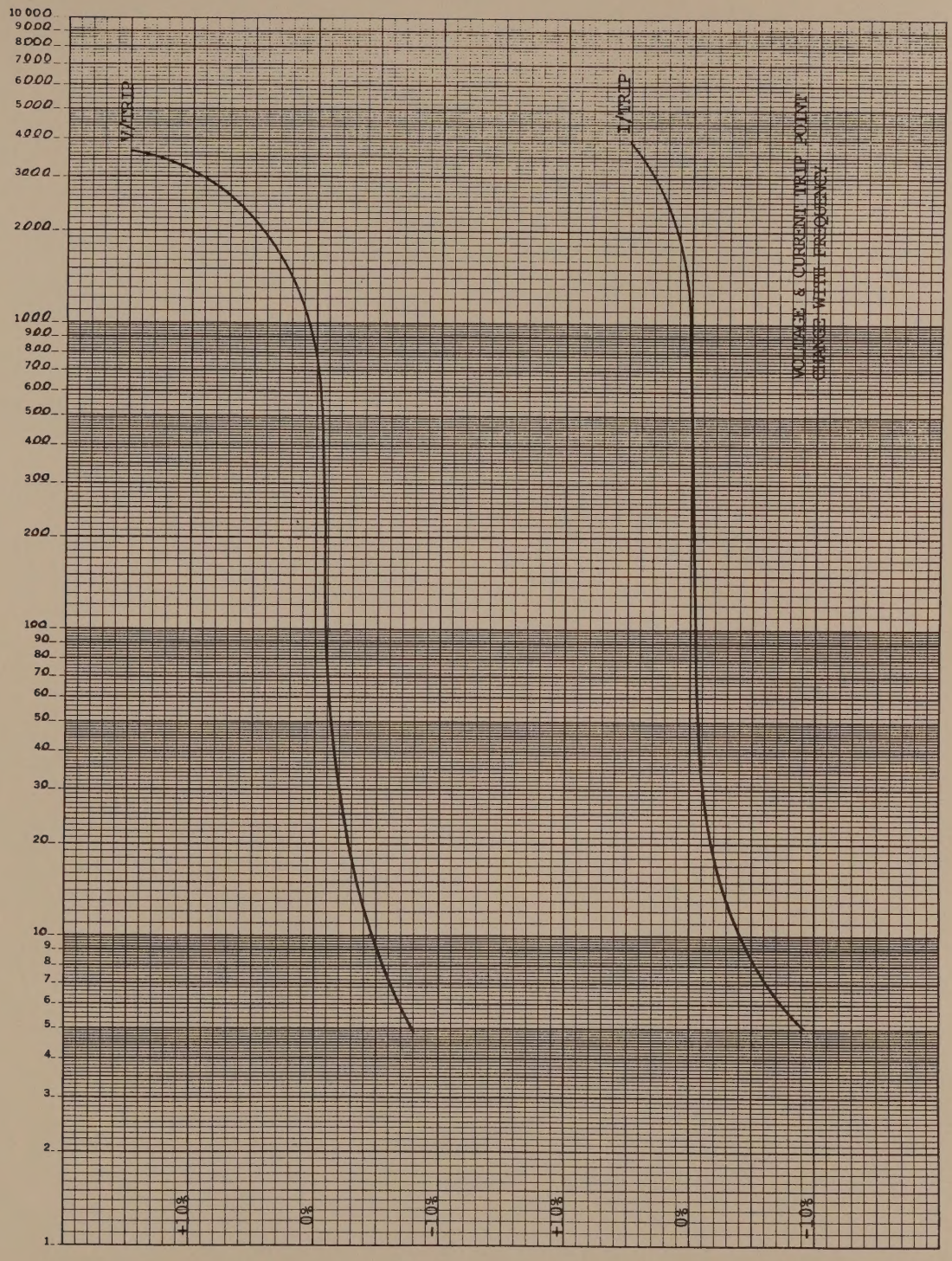
Chart A5 plots the change in the voltage and current trip points with operating frequency.

FREQUENCY RESPONSE

GAIN/PHASE RESPONSE



POWER MODULE CURRENT V.S. TIME



V & I TRIP POINTS V.S. FREQUENCY

NOTES:

{ end of manual M706710 }

MP MASTER
MA29145